THE TECH ENGINEERING NEWS

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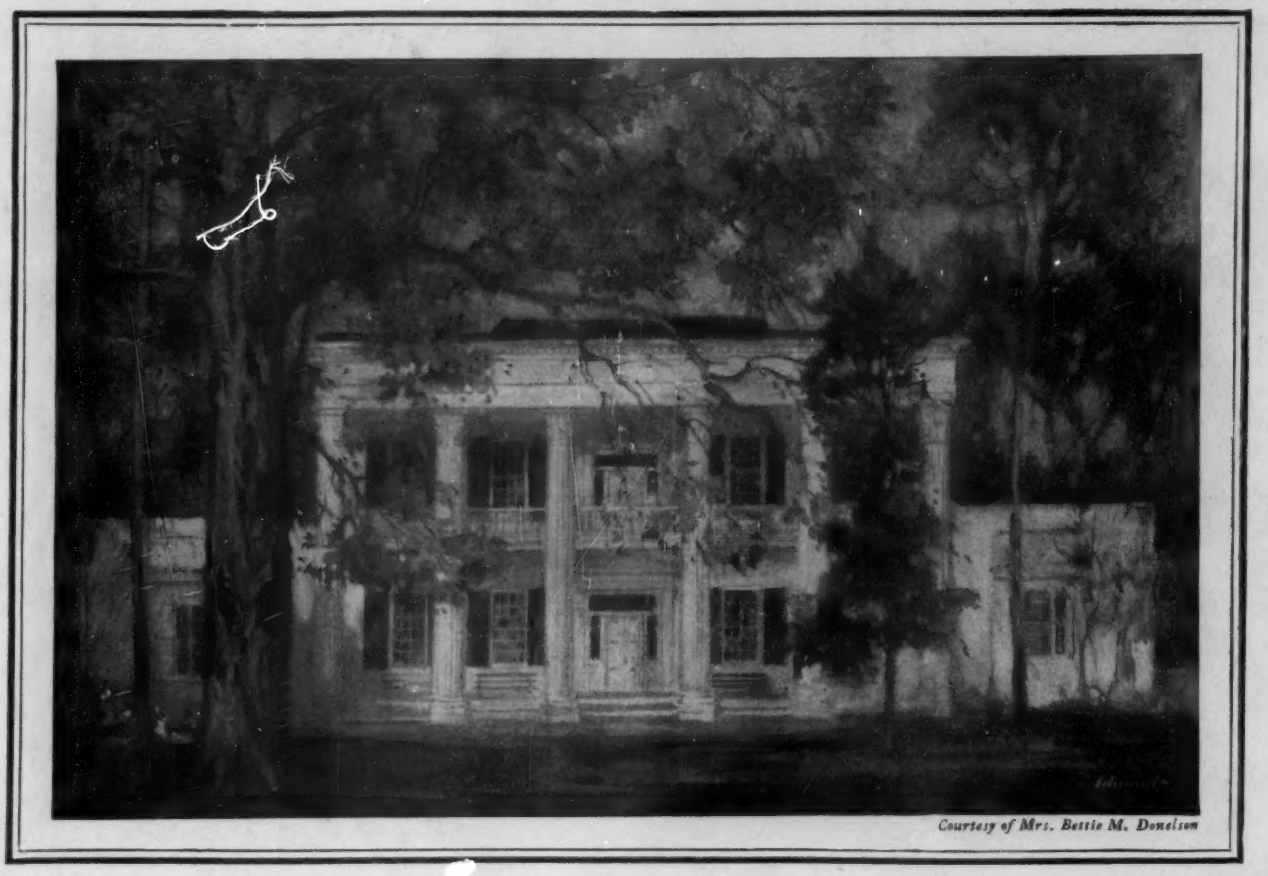
THE CAMDEN MAIN TOWER OF THE DELAWARE RIVER BRIDGE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS



Courtesy of Mrs. Bettie M. Donelson

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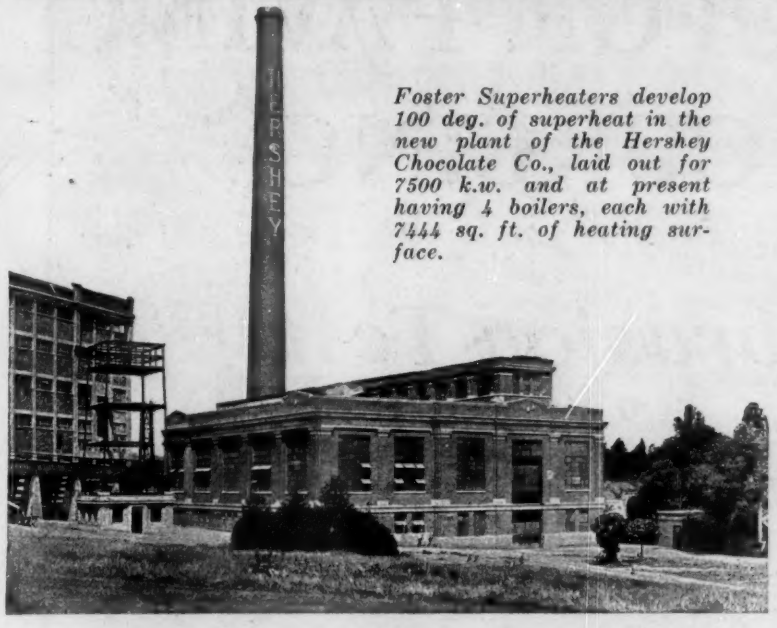
Reducing power costs in every industry



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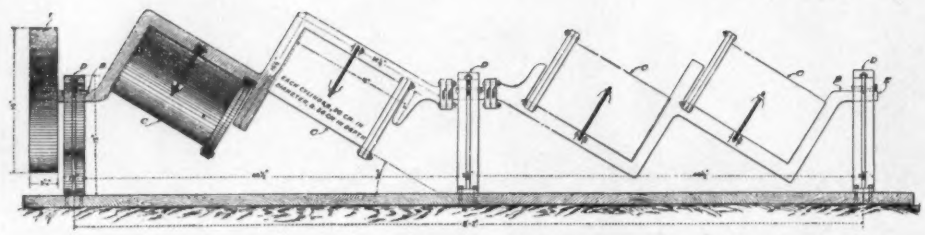
GRANITE FOR PAVING AND CURBING

The Abrasion Test



The Deval Type Abrasion Machine

The material is broken into pieces as nearly of the same size and shape as practicable so that approximately 50 pieces shall weigh (after thoro drying) to within 1 gram of 5000 grams. The number of pieces should not exceed 60 or be less than 40. After weighing, the sample is placed in one of the cylinders of the Deval machine and given 10,000 revolutions at the rate of 30 a minute. At the conclusion of the test the sample is screened on the $\frac{1}{16}$" screen, the material retained washed clean of dust, dried in an oven and weighed. The difference between the first weight and the last represents the wear as determined by this test. The per cent of wear is then easily determined and 40 divided by the per cent of wear gives the French Coefficient.

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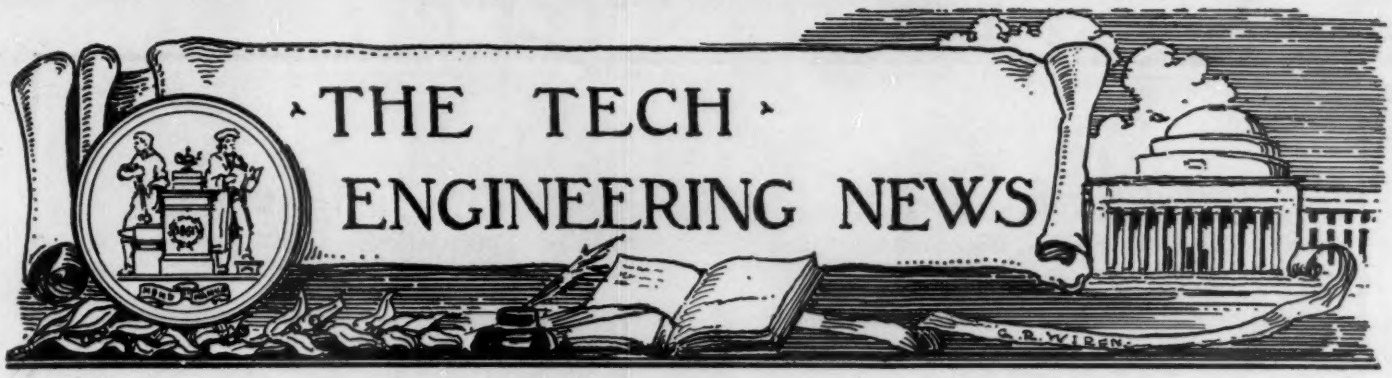

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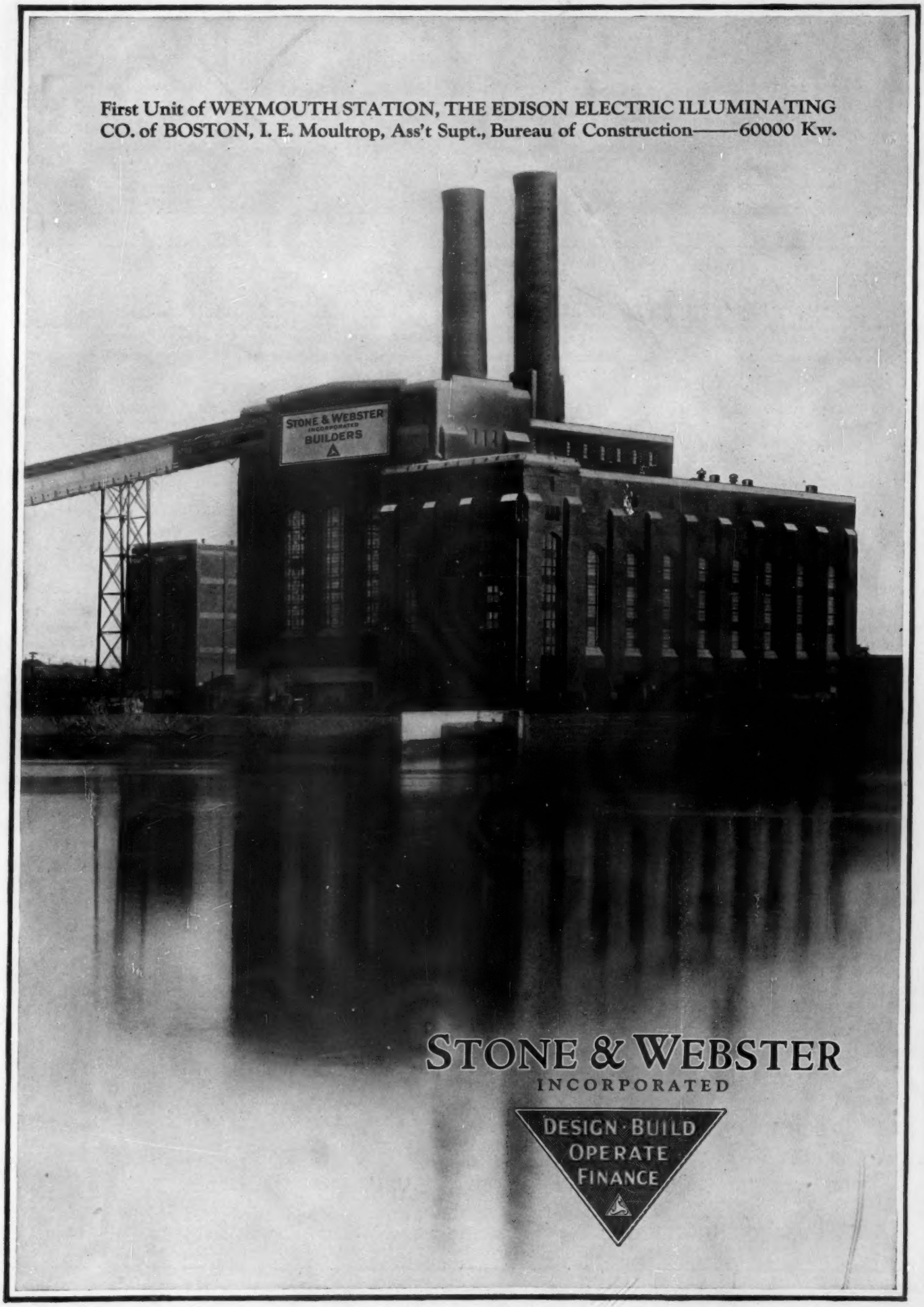

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THE TECH
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THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME VI APRIL, 1925 NUMBER 1

Cuckoo Ideas

Proving that the man at the top is never "cuckoo"; that he thinks independently and pays the man who has memorized cuckoo ideas

By F. ALEXANDER MAGOUN, '18
Instructor, Department of Naval Architecture, Massachusetts Institute of Technology

IT was Prof. Files of Tufts College who told me the parable of the cuckoo bird. It does not build a nest for itself, but lays eggs in the nests of other feathered folk. The wren, for instance, is a conscientious mother who often unwittingly performs the tedious task of sitting upon the cuckoo's eggs until they hatch. By this arrangement the little legitimate wren children do not even share equally, for they are smaller and more feeble than the cuckoo fledglings, who crowd them out with their spoon-shaped bills after the manner of these subway people with elbows.

So it is with our ideas. If we do not brood over them until they have been warm long enough to peck at the shell and be let out, but leave them to be hatched and developed by some more diligent bird, men will describe us with the simile of the cuckoo. Or again, if we spend our time hatching the cuckoo ideas of other human birds our own work will suffer, and men may even say that we are cuckoo.

But to carry the metaphor still further, might it not be said that within the interwoven ideas which form the structure of our brain nests, those things we have memorized from the opinions of others are the cuckoo eggs, and whatever we have thought out for ourselves constitutes the wren eggs? As before, the wren children are smaller and more feeble than the cuckoos.

The man at the top is never cuckoo. He thinks independently and pays a modest salary to the man whose memory will give all except that little new item which would wreck the enterprise. How many undertakings have failed because nobody stopped to think about the effect of heat making the metal expand!

Thought, earnest, plodding, brain-racking thought, is the most precious and the rarest achievement of mankind. Above the door through which an applicant must pass to reach Mr. Edison are the words, "A man will resort to almost any expedient to avoid the real labor of thinking." The expedient resorted to by college students is a trinitarian artifice—skim, cram, bluff.

Thought is a comparison of ideas. Thought is earnest reflection; in fact, one might even go so far as to say that study without reflection is useless. What are the assumptions? What is the logical outcome of the theory? Are there any special cases? What are the limitations? There is a vast difference between knowing facts and understanding them.

Some years ago a well known Technology professor recounted to me an experience of his which illustrates this difference admirably. His older son came home with the justly famous algebra problem concerning the time required to fill a tank when all pipes are flowing if the rate of filling or emptying it by the individual lines is known. The younger son, then only recently introduced to fractions, became interested as his father endeavored to direct the reasoning of the high school student, and asserted that he could do the problem. In ten minutes he secured the correct answer, using the fractional method, whereas his older brother required three-quarters of an hour to set up and solve a few algebraic equations. Since the sophomore class in physics was studying hydraulics at the time, the professor put the problem on the board the next morning for its consideration. In one hour not a single man was able to obtain the answer. These college students knew about fractions and simultaneous equations, but they did not really have a grasp of their fundamental underlying principles. They were trying to remember a formula instead of thinking in terms of common sense.

Most of us observe, but we do not analyze. We study by trying to memorize instead of by trying to understand, and there is no benefit in memorizing a mass of facts, the meaning of which we do not grasp, particularly since we are more likely to remember the things which we really do understand. Those few men who interpret what they see become either famous or wealthy.

A Worcester manufacturer of belting was spending his vacation on an old farm. Desiring to wash out a huge copper kettle he threw some rags into it, stuck the hose nozzle over the edge, and went to turn on the water. When he returned, the rags were traveling round and round inside the kettle at a lively rate, driven by the stream of water. Any ordinary man, educated or not, would have continued with the task before him, perhaps developing a boyish interest in watching the rags move. The manufacturer stood for a few moments of analytical reflection, shut the water off, and went into the house to tell his wife that he had invented a washing machine.

And there was that young engineer in Michigan, who perceived, as he was walking through the deep woods, that the needle of his compass dipped toward the earth. Most of us would have thought it peculiar and forgotten the incident, even though everyone of us knows that iron will deflect a compass. This man borrowed money, bought the land, and eventually became enormously wealthy from his iron mines.

(*Continued on page 28*)

The Delaware River Bridge

Some interesting facts on the link, now under construction, which will connect the states of Pennsylvania and New Jersey in 1926

By G. E. WALLIS
Page Fence and Wire Products Assn., Chicago, Ill.

AFTER decades of endeavor, the two great states of Pennsylvania and New Jersey finally will be linked.

This link will take the form of the world's greatest suspension bridge, joining the cities of Philadelphia and Camden, N. J., and it will be completed and open to the public on the nation's 150th birthday—July 4, 1926.

The dream of joining Pennsylvania and New Jersey at Philadelphia is an ancient one, dating back over a century. In 1818 an application was made to the legislatures of both states to build a bridge part of the way across the river, from Camden to Windmill Island, a distance of 2,200 feet, the remaining distance to Philadelphia to be covered by a ferry. This project was dropped, but a bridge plan was renewed in 1870, the projected structure at that time being designed to be of a height of 105 feet above the mean water level of the Delaware River at that point.

This project also proved abortive. But, after much agitation, the legislatures of Pennsylvania and New Jersey, in 1919, created the Delaware River Bridge Joint Commission, and on September 24, 1920, this commission engaged a board of engineers for the purpose of preparing a preliminary report.

This board of engineers, headed by Ralph Modjeski, one of the most eminent bridge engineers in the world, and having as associates George S. Webster and Laurence A. Ball, also eminent bridge engineers, incidentally, is the board which is now constructing the bridge.

It is unnecessary to go into intimate details regarding the plans for this giant structure, but it will suffice to say that from this date onward, preparations for its construction proceeded apace, and there was little delay in the work.

A few facts and figures regarding this great bridge will be of interest. Its main span is 1,750 feet, as compared with 1,595½ feet for the Brooklyn Bridge; 1,600 feet for the Williamsburg Bridge, and 1,470 feet for the Manhattan Bridge.

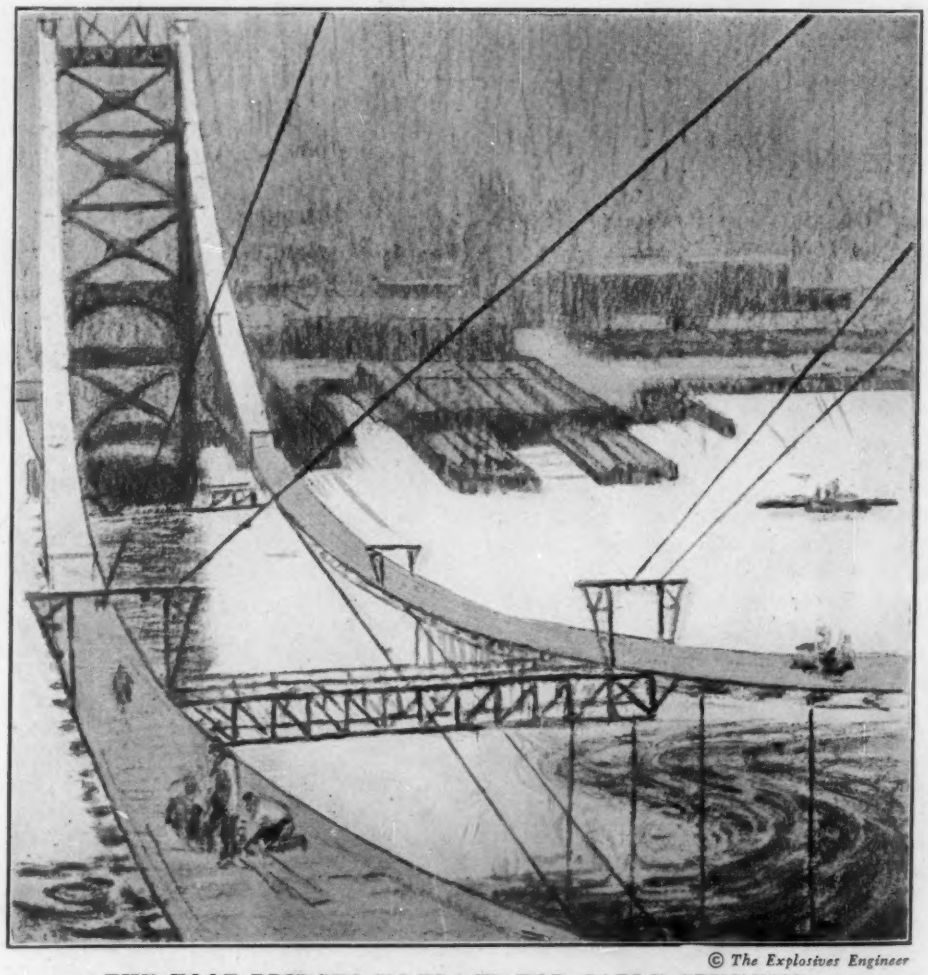
Differing from the three New York bridges, which employ four suspension cables each, the new Delaware River Bridge employs but two, but these are of a diameter of 29⅞ inches each, as compared with 15½ inches for the Brooklyn Bridge cables; 18¾ inches for the Williamsburg, and 20¾ inches for the Manhattan Bridge cables.

Also, these suspension cables are far stronger than those of any of its three principal rival bridges, inasmuch as each cable for the Delaware River Bridge uses 18,666 strands of galvanized wire, as against 5,296 strands of galvanized wire for the Brooklyn Bridge, 7,696 strands of bright wire for the Williamsburg Bridge, and 9,472 strands of galvanized wire for the Manhattan Bridge.

These suspension wire ropes, therefore, give the Delaware River Bridge a unit strength of 215,000 pounds to the square inch, as against 177,000 pounds for the Brooklyn Bridge and 210,000 pounds each for the Williamsburg and Manhattan bridges. The weight of the cables in the Delaware River Bridge is 7,000 tons, as against 3,272 tons for the Brooklyn Bridge; 4,344 tons for the Williamsburg Bridge, and 6,108 tons for the Manhattan Bridge. The width of the new bridge is one hundred twenty-five feet six inches, and its total length will be 9,500 feet, which is 2,200 feet longer than the Williamsburg Bridge, its next rival in size.

Thus, this great bridge will be almost two miles in total length, and it will have a vehicular capacity of 6,000 per hour. On its roadway will be carried two surface car tracks and two rapid transit tracks, with a width of 125 feet over all, while it will also carry two sidewalks, each 10 feet wide, on the river span, and 16 feet on the approaches, and a roadway 57 feet wide.

When the cost of this bridge is set down in figures, it is astounding. The total cost is estimated at $32,783,000, making it one of the costliest construction projects of modern times. This, of course, is not the actual cost of the bridge construction itself, but includes all other costs. These, itemized, show that the main bridge will cost $13,355,000; the Philadelphia approach, including station, plaza, etc.,



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THE FOOT BRIDGES IN PLACE FOR CABLE SPINNING

$3,579,000; the Camden approach, $2,639,000; the electrical equipment for lighting, maintenance plant, etc., $250,000; an allowance of 5 per cent for contingencies, amounting to $991,000; an engineering cost of $1,249,000, being 6 per cent of the total bridge cost; and an administrative cost of $416,000, being 2 per cent of the bridge cost, this bringing the total construction cost of the bridge to $22,479,000, to which must be added $10,000,000 for the acquisition of real estate in Philadelphia and Camden, and $304,000 for contingencies and cost of acquiring this real estate. These make up the total estimated cost of $32,783,000.

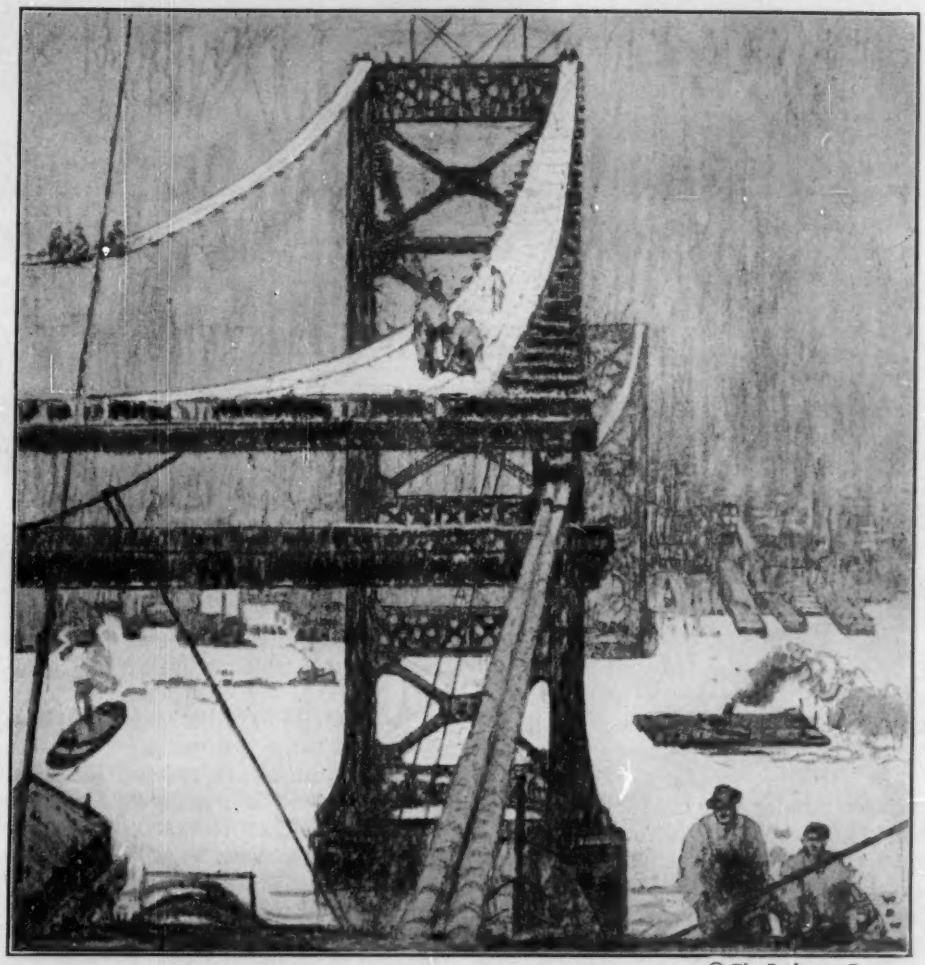
The method of construction of this bridge is decidedly interesting. Naturally, it centers mainly about the wire to be used, as the bridge is to be hung or suspended on this wire. Therefore, it is well to note that either one of the two main cables, whose diameter is 29⅞ inches each, is sufficiently strong to swing the great Leviathan, weighing 54,000 tons, clear of the water. Each cable contains 61 strands of 306 wires each, which makes up the total of 18,666. As a result, there is an astounding total of 25,100 miles of single-strand wire in this bridge—enough to girdle the earth at the equator and still leave more than enough wire to stretch from Pittsburgh to New York.

The steel used in this wire is acid open hearth of rigid chemical specifications. These demand that every ingot, billet, bundle of wire rod, and bundle of wire be as near perfect as modern engineering and mechanical skill and treatment can make them.

Thus it is interesting to note that after the final cold drawing, the bright wire varies in gauge less than 3/1000 of an inch. It is so hard that it will cut ordinary glass, and yet it can be bent cold around a rod 1½ times its own diameter without sign of fracture.

The regulations covering the galvanizing of this wire are equally rigid. The zinc coat is 99.75 per cent pure, and this is believed to establish a record for the use of this process. The gauge of the galvanized wire is only 5/1000 of an inch greater than that of the wire, and its specifications demand that it must stand bending about a two-inch mandrel without visible cracking, and also four one-minute immersions in standard copper sulphate solution.

The testing and inspection of this wire is extremely careful. The end of each bundle of finished wire, continuous for 2,000 feet without splices, is carefully tested to the breaking point for tensile strength, elongation, and yield point. The Page Steel & Wire Company has been able to better the specifications, which call for 215,000 pounds per square inch, an elongation of 4 per cent in 10 inches, and a yield point of 144,000 in pounds per square inch. The average tensile strength of the wire actually produced, according to the tests, is 223,000 pounds per square inch, the strongest wire yet used in bridge construction.



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THE TWO GREAT 350-FOOT TOWERS IN PERSPECTIVE

The main span of the bridge is 1,750 feet, as compared with 1,595½ feet for the Brooklyn Bridge; 1,600 feet for the Williamsburg Bridge.

The bundles of wire are spliced on reels of 80,000 feet each, or 8,000 pounds of wire. The splices are made with sleeves with right and left hand threads, and the wire ends are mitred, which locks them against unthreading. Though each cable is designed to resist a pull of only 36,700,000 pounds, tests of strands of this wire show a tensile efficiency of more than 95 per cent of individual wires, which would give each main cable a tensile strength of something more than 100,000,000 pounds, by far the strongest cables ever made.

Spinning these great cables naturally presents some unusual difficulties. The wire is carried across the river in the usual fashion, on traveling sheaves, or trolleys, fastened to an endless cable. Two cables and four trolleys are used, each cable carrying two trolleys. When a strand is begun, the end of wire from a reel is fastened to an anchor shoe, and the loop, or bight, is passed over the trolley wheel. At the same time, a similar operation is taking place on the other shore. The cable, operated by a motor, is then set in motion, and carries either loop to the opposite shore, where it is passed over the anchor shoe. Thus each trolley adds two wires to its strands at each crossing.

The suspender ropes, also furnished by the American Cable Company, will number 596. They are made with a 7 x 7 wire rope center, surrounded by 6 strands of 37 wires each, and have a nominal diameter of 2¼ inches. The suspender ropes will weigh 400 net tons, which, with the cables, will give the suspension elements a total weight of 7,400 tons.

Thus it is readily seen that this great bridge, realizing a century-old dream and uniting two great states, will in itself take rank as an industrial achievement worthy of the two great commonwealths that it links together in bands of steel.

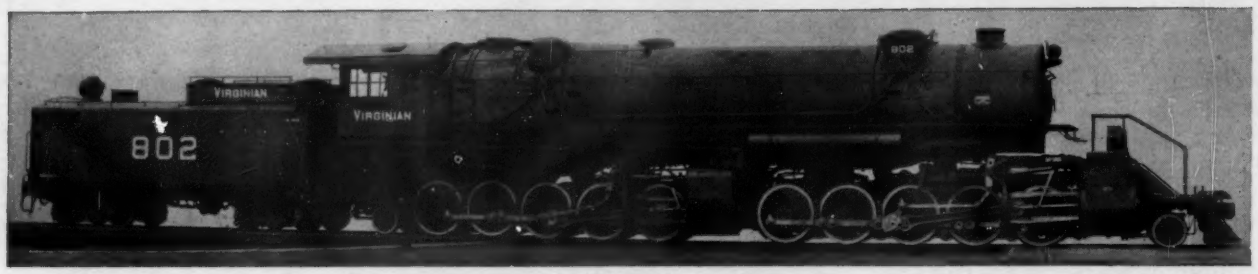

Figure 4
STEAM MALLET TYPE LOCOMOTIVE NOW USED ON THE VIRGINIAN RAILWAY

The Virginian Electrification Project

A coal carrying railroad turns to electricity as a solution of its hauling problems—Steam and electric power compared

By E. B. FITZGERALD and G. K. SHANDS, '23
Westinghouse Electric and Mfg. Co.

THE unusual success which was attained by the electrification of the Elkhorn Grade on the Norfolk & Western Railroad in 1914 was directly responsible for the decision on the part of the Virginian Railway Company to electrify 134 miles of their main lines which includes 213 track miles, lying between Mullens, West Virginia, and Roanoke, Virginia. This fifteen-million-dollar project is now well under way, and it is expected that the electrified section will be put into operation next summer. In discussing the electrification of the Virginian Railroad, the subject matter will be dealt with in the following order: first, a brief description of the location; second, an outline of the power plant equipment and transmission system; third, a general description of the locomotives and their equipment; fourth, a comparison of results expected under electric operation to those obtained under the present steam system.

The Virginian Railroad, which is essentially a coal carrying road, extends from Norfolk, Virginia, to Deepwater, West Virginia, where connections are made with the Chesapeake & Ohio Railroad. The line is single track, except from Mullens to Clarks Gap. This section is double tracked, as it includes the heaviest grades of the whole system. This road and its branches winds its way into the very heart of the rich coal fields of Virginia and West Virginia. The coal from the various mines is collected in the Elmore Yards at Mullens, West Virginia, and it is then taken to the coal piers at Norfolk, Virginia, for shipment by water. It is from these piers, the largest of their kind, that vessels carry coal to all the ports of the world. Since the heaviest grades are encountered between Mullens and Roanoke, it is evident that this stretch of track governs the maximum capacity of the whole system. Hence, in order to increase the tonnage and speed over this mountainous division, the Virginian Railway Company decided on electric traction as the best solution of the problem.

In describing the power plant equipment and transmission system to be used on the Virginian Railway, the former will be discussed first. The railroad company is now installing a steam turbo-generator station of 60,000 kilowatts capacity on the New River at Narrows. This is an ideal site since it is practically located at the load center of the section that is to be electrified. This power plant will be equipped with four Westinghouse, 25-cycle, three-phase, 11,000-volt turbo-generators with a maximum single phase rating of 15,000 kilowatts each. Three units will be sufficient to carry the maximum demand of the system, the fourth being reserved for emergency purposes. Surface type condensers will be installed and an ample supply of water for condensing purposes is available from the New River. The high tension switching equipment along with the transformers for stepping up the voltage will be located outside the building. Four single-phase, water-cooled, step-up transformers rated at 10,000 kva., 11,000 to 88,000 volts will be used.

Figure 2 will give the reader a good idea of the transmission and distribution system which will be used on the Virginian Railroad. Two 88,000-volt, single-phase transmission lines will connect the generating station with seven step-down transformers located along the section that is to be electrified. The step-down transformers will be of a special type with two windings on the secondary. One of these windings will be connected to the 11,000-volt trolley-rail circuit and the other is connected to a feeder-rail circuit with a potential of 22,000 volts. Auto transformers are connected between the feeder and the trolley circuits with a tap on the windings per-

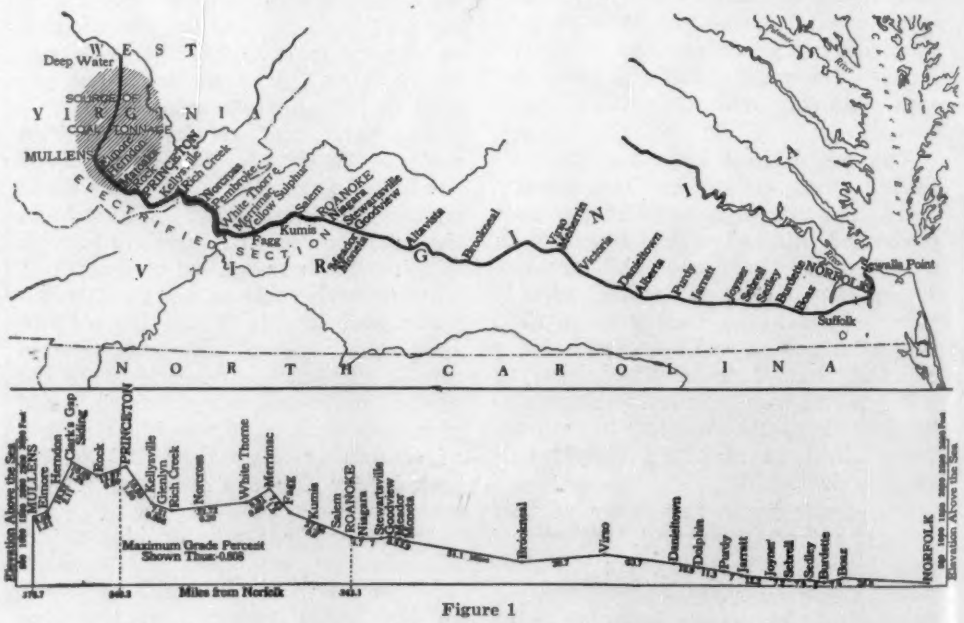

Figure 1
MAP AND PROFILE OF THE VIRGINIAN RAILWAY SYSTEM

manently connected to the rails. The auto transformers and the secondaries of the step-down transformers are so arranged that when operating conditions make it advisable, the trolley rail potential can be increased to 22,000 volts.

The locomotives which are being built for the Virginian Railway are of the split phase type and are designed for multiple unit control. They will be the same as the new Norfolk & Western locomotives shown in figure 3, except that the Virginian locomotives will be composed of three motive power units instead of two, each unit weighing 206 tons. Each motive power unit is equipped with a pantagraph, circuit breaker, transformer, synchronous phase converter, two 1000-horsepower, three-phase wound-rotor, induction motors, liquid rheostat and the necessary auxiliary and control apparatus. Current is collected from the 11,000-volt trolley wire by means of a pantagraph which, in turn, is connected to the primary of the transformer through an oil circuit breaker. The voltage is stepped down to a value suitable for the motors by means of an oil-insulated, forced-cooled, 2,350-kva., 10,500 to 1,500 volts, single-phase transformer. The coils on the primary of the transformer are connected in parallel. However, as mentioned in the previous paragraph, the trolley voltage can be increased to 22,000 volts and these same transformers can be used by changing the primary connections from parallel to series. The single-phase power is changed into three-phase energy for the motors by means of the synchronous-phase converter. The latter is essentially a two-phase, wound-rotor, induction motor. One phase of the converter, known as the motoring phase, is connected across the secondary of the main transformer. Hence, when single-phase power is impressed on this phase, a voltage is induced in the generating phase which is displaced ninety degrees from that of the motoring phase. The generating phase is so connected to the transformer that a Scott or T connection is obtained and thus, three-phase power is available for the traction motors. At starting, the phase converter is brought up to speed by means of a single-phase commutator type motor which is directly connected to the converter. The converter is protected by several relays and interlocks and is not allowed to be thrown on the line until it reaches synchronous speed. The operation of these relays is dependent upon the voltage built up in the generating phase of the converter. Conseqently, the switches between the transformer and the converter cannot be closed until the converter is in synchronism with the line. After the converter is connected to the line, the starting motor is changed over to a direct current generator which excites the field of the converter. It is possible to change the field strength of the converter by varying the field on the generator which is excited from the direct current control circuit. Since the converter is of the synchronous type, the locomotives can operate at a very high power factor.

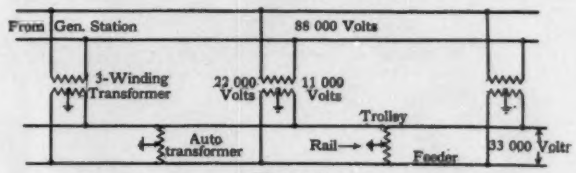

Figure 2
TRANSMISSION AND DISTRIBUTION SYSTEM

The induction motors which will be used on the Virginian locomotives are well adapted for electric traction on heavy grades. This type of motor is simple, rugged, and has a high starting torque. Furthermore, it inherently becomes an induction generator when the locomotive drives the motors at greater than synchronous speed on the down grade and thus delivers power back into the line. The stators of these three-phase, wound-rotor induction motors are wound for four and eight poles. By means of a pole change-over switch, two constant speeds of fourteen and twenty-eight miles per hour are obtainable. Slip rings connect the rotors of these motors to fixed plates in the liquid rheostat. Further variation of speed is obtained by changing the resistance in the rotor circuit. This is accomplished by varying the height of the electrolyte in the liquid rheostat. That is, raising the height of the electrolyte increases the speed, whereas lowering the liquid decreases the speed. Power from the motors is transmitted to the drivers by means of pinions, flexible gears, jackshafts and side rods.

As previously stated, the locomotives for the Virginian Railway are designed for multiple unit control. This control system is of the electro-pneumatic type and should operating conditions in the future make it necessary, four motive power units can be operated as one locomotive. The units are connected electrically by means of train jumpers, thus, the engineman in the operating end of the locomotive can control the perform-

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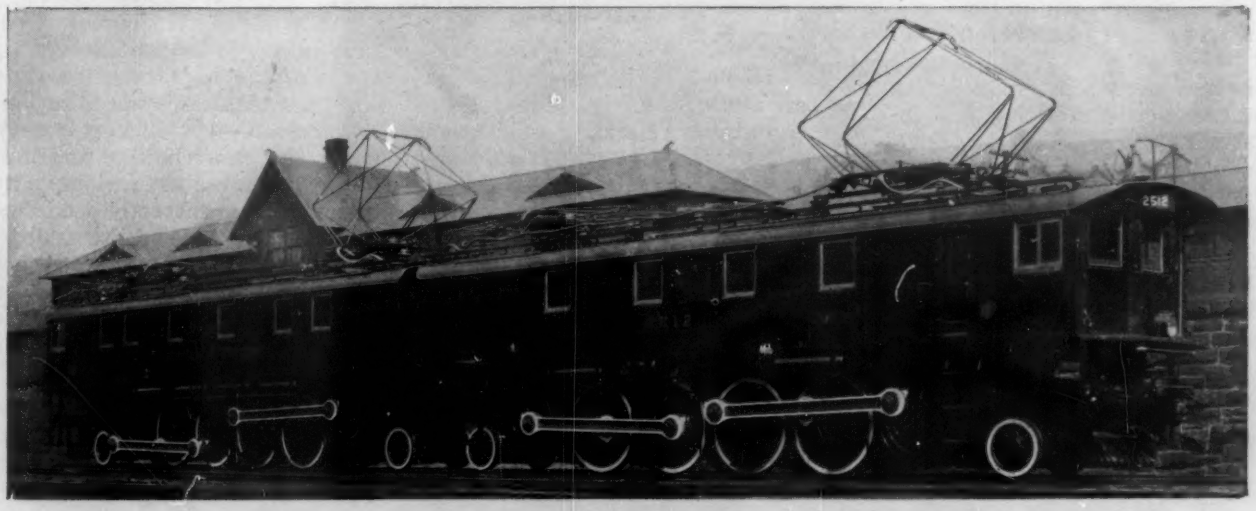


Figure 3
ONE OF THE NEW NORFOLK AND WESTERN LOCOMOTIVES
The locomotives for the Virginian Railroad are similar, except that they will be composed of three motive power units instead of two, each unit weighing 206 tons.

The Better Condenser Tube

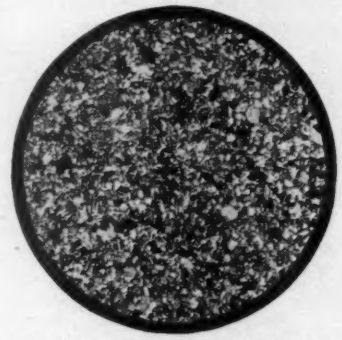
Modern methods in overcoming strains and corrosion in tubing—including a discussion of the manufacture of Admiralty and Muntz metal

By FRANCIS O'L. KILLORIN, '17
Production Dept., Scovill Mfg. Co., Waterbury, Conn.

MUCH has been written to inform us of the superiority of brass tubing for conveying hot and cold water in residences and office buildings: of its durability—long life; its ability to withstand corrosion, because it is not affected by those elements that would consume iron pipe. The tendency of iron to revert to the form in which nature presents it to us—an earthy oxide—

YELLOW BRASS, VERY SOFT, COARSE GRAIN (75X)

YELLOW BRASS, ROLLED VERY HARD—STRAINED (75X)



ADMIRALTY METAL—WILL NOT "SEASON CRACK" (75X)

renders it unfit to combat the elements, air and water. Water contains air and mineral substances which promote a corroding and cementing action that soon closes an iron pipe of small diameter. Excavations in many lands have revealed hundreds of bronze and copper pieces that were in use 5000 years ago—they may have become corroded on the surface, but that is all—the metal underneath remained solid. QUID AERE PERENNIUS. Everyone knows that all exposed iron requires a protective covering of some kind: paint, zinc (galvanized or sherardized), tin, enamel, etc. These outside coverings are not permanent—they wear off. A ganlvanized iron pipe may show a perfect exterior but that does not insure it against internal attack.

Brass and copper pipe require no protective coat; neither do they accumulate sediment or corrode within—they brave the elements and remain free. The arguments in favor of brass pipe are sound if the pipe is sound. It may well outlast a lifetime.

The Condenser is a very important unit in a power house, on a battleship, or an ocean liner, and it is only as good as the tubes within it. To give service in any of the above installations Condenser Tubes must be sound chemically and physically—they fail because of two conditions:—viz., corrosion; "season cracking."

Corrosion cannot be prevented entirely; it is a form of decay—that is, nature applying its pressure to break down a metal. A tube of a different alloy, or a change in other conditions may be the remedy. A corroded tube may be deprived of its zinc, leaving a porous form of copper that will be weak, brittle, easily broken with a hammer—this would indicate that an improper alloy had been used.

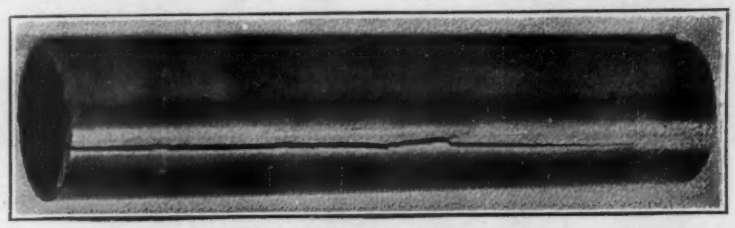
"Season Cracking"; dirt inclusions; unsound metal, are due to faulty manufacture. The former is serious, but can be eliminated entirely—it is unnecessary. "Season Cracking" is due to strains induced at the time the tube is drawn, which if not relieved by careful, accurately controlled, annealing, results in a longitudinally split tube. This same condition may obtain in goblets, vases, or tubes of glass that have not been relieved of their working strains. When conditions are right for it, the goblet or vase will fall apart, breaking into two or many pieces.

Two alloys find their way into Condenser Tubes: namely, Muntz Metal and Admiralty Metal. Specifications adopted by the United States Navy, and the American Society of Testing Materials, designate this composition for tubes of Admiralty Metal: copper, not less than 70.00 per cent; tin, not less than 0.90 per cent; iron, not more than 0.60 per cent; lead, not over 0.075 per cent; zinc, the remainder. These mean that only the highest quality of metals may be used.

Careful processing and supervision on the part of the manufacturing forces can convert the above alloys into tubes of excellence. If, however, mechanical and metallurgical operations are not right, tubes will fail in spite of the fact that the alloy may be made up of the finest metals, free from impurities, and in correct proportions.

Muntz Metal Tubes are not so resistant to corrosion, being suited more to fresh water conditions. The structure of Admiralty Metal, however, is such as to give it first rank among the commercial alloys that may be used in a condenser. Admiralty Metal is included in that group of higher copper alloys known to technologists as Alpha brass. By special heat treatment it is possible to eliminate the more corrodible Beta constituent of the Muntz Metal alloy.

The size of crystals (grain size) found in the metal structure of a good tube is not to be passed over lightly. If the crystals are too large, the metal will not meet the specifications for compression—it will be too soft. The grain size must be fine and uniform, to offer its greatest resistance to corrosion. When correctly made, a tube may be bent, twisted, expanded, hammered, compressed and it will not give way—neither will it "season crack." In Muntz Metal Tubes, the grain size



"SEASON CRACKED" TUBE

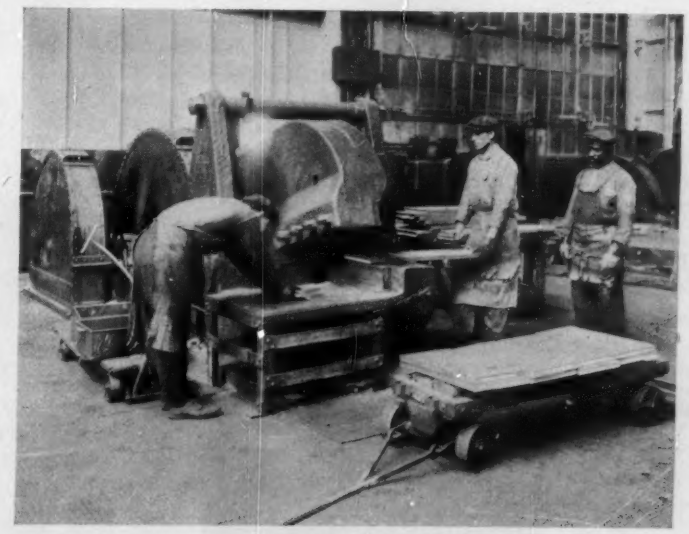
must be an average not exceeding 0.03 millimeters (0.00118 inch). In Admiralty Metal Tubes they must not exceed 0.02 mm. (0.00078 inch).

Two methods of manufacturing Condenser Tubes will be described. A third method is that of casting the alloy around a compressible core of mud-covered straw suspended in a mold—it is not used in these works.

The processes adopted by the Scovill Manufacturing Company are capable of producing sound tubes having the highest of physical and chemical properties. Admiralty Metal Tubes are made by cupping a disk of metal; Muntz Tubes, from large diameter rods extruded from billets.

To make sure that each charge is correct, one man is made responsible for one metal component—he weighs no others. This is the first step in supervision to control quality. The metals are melted in electric furnaces where the temperature is controlled by means of thermo-couples. (Only those of platinum, platinum-rhodium wire, made and standardized by the Electrical Laboratory are used.) Every caster is instructed as to their care and use, but no metal is poured until the foreman says that it may be. The temperature must be correct, so must the molds, runner box, and all the other conditions attendant upon casting sound metal. There is no guess work about it; it isn't necessary—nor permitted. When the alloy has reached the temperature proper for it, it will be skimmed free of dross, and poured. The bars or billets will be numbered, sampled, piled, and held until the laboratory renders its report.

CASTING SHOP
The tops of the furnaces are level with the floor. The metal is being skimmed.



ALLIGATOR SHEARS
The shears remove the "gate" end and cut the bar at its middle.

Admiralty Tubes

Bars of correct metal composition proceed to alligator shears, where the top end (called "gate") is removed, and the bar cut at its middle. (This gate end contains dross not entirely removed when the molten metal in the furnace was skimmed.) Careful examination is given the two clean surfaces thus exposed, for flaws or other defects.

Each bar is rolled to about ¾ inch, both sides of it planed smooth, then turned over to the inspectors. Inspectors for this work must be careful men on the watch to remove any metal that might be undesirable. The milling machines remove chips in about the same way a planer of wood does—the chips leaving the machine through pipes connected to a large exhaust fan, are collected in the same way sawdust is. The first rolling is called "breaking down." It will be noted that up to this point the metal has already been examined three times.

The rolls change the shape of the bars—make them thinner and longer. In doing this the entire structure of each bar becomes altered. The crystals are squeezed and broken; strains are imparted, and we have metal, not soft, as it was, but hard, striated and spring-like. To roll it more would be injurious, because overstraining results in split metal. Knowledge of these conditions has established the limits for each alloy. A metal like copper may be rolled much more than brass without being hardened or damaged. So may aluminum.

It is now necessary to restore conditions within the bars to equilibrium—this is accomplished by heating them to about 600° Cent. There will be a readjustment: the distorted shape of the crystals disappears and those of natural form grow. The spring-like temper gives way to metal that is softer. All internal strains will have been removed when the bars have been exposed for the required number of minutes. Too long exposure, or too high a temperature, results in very large crystals—metal too soft and weak. Annealing furnaces are called "muffles." They are ovens of brick, large enough to hold two very long iron pans on which the bars have been piled. (Muffles are a form of reverberatory furnaces, fired by wood, oil or coal.)

The pans are drawn and withdrawn by chain wound on an electrically operated drum. When tooled outside, the bars are given a bath of diluted sulphuric acid to remove oxides formed in the muffle, then washed, and passed on to another group of rollers, who bring it down to the required gauge. This done, it is re-annealed, pickled, washed, and dried.

The next six operations are performed by powerful presses—they convert a flat metal disc into a cup 54 inches deep.

The first press cuts one disc, 12 inches in diameter, at each stroke, as the bar of half-inch metal is pushed forward, which pile automatically, in pans, and are taken to an inspector. This inspection is as thorough as it can be made, to reject any discs showing defects, not encountered previously; for the next operation is that of changing the disc to a cup, by a squeezing, forcing action, and only perfect metal can stand such an ordeal. Metal containing hidden flaws will open in the press—an occurrence that is sometimes disastrous to the dies. After this the tube maker knows that he has only good metal; the unfit is not able to stand the strain.

The cups measure about seven inches diameter by six inches deep.

(*Continued on page 22*)

Open House Night

A rare opportunity for the "outsider" to get an idea of what Technology is, and just what it is doing in the advancement of education

By H. E. WEIHMILLER, '25
Chairman, Combined Professional Societies, Massachusetts Institute of Technology

TO the average "outsider" or person not directly connected with the Massachusetts Institute of Technology, Tech looms up as a group of massive buildings, silent in aspect and appearance, yet radiating the feeling that great activity must be going on inside. An exterior view, which is generally all that the public at large obtains, gives little or no insight into the life and appearance of the interior. At times, photographs and articles are published about Technology, giving the layman the impression that the Institute is more an inferno of seething chemicals and massive machines operated by mysterious hands than an orderly technical institution where thousands pursue their studies.

On Thursday evening, April sixteenth, the Massachusetts Institute of Technology will be opened to the public and everyone interested will be given an opportunity to view the Institute in complete operation. Trained guides will conduct groups of visitors through the various laboratories, shops and places of interest with the purpose of acquainting them with the nature of Institute life and activities. During the year, many people come to Tech requesting to be "shown through" the place that has made such a great name for itself and its students in the scientific world.

Three years ago, the Combined Professional Societies of M. I. T. inaugurated what has come to be known as Open House Night. The success of this undertaking and the interest it aroused has been so gratifying that it has become an annual function. On this night, the most ideal opportunity is available for visiting Technology, for at no other time during the year may so much be seen at one time. The Open House Night Committee, co-operating with the Institute officials and faculty, has arranged to have every main laboratory, shop, and hall open for inspection with tests and experiments in operation at the more important ones, and the work of students in every department on display. Special exhibits will be on view besides various other interesting features arranged especially for the visitors.

As the visitors enter the main lobby of the Institute, they will be met by the Reception Committee, which will assign a student guide to each small group and designate a route to be followed. Keeping in mind the short time available and the multitude of things to be seen on this tour, the routes have been carefully planned to include only the points of greatest interest, while those desiring to see certain parts of the Institute will be assigned special guides on request. To insure against congestion and for information, students will be stationed at points in the corridors and information booths will be at all entrances and exits. Following their "Route Guide," the groups will pass from one point to another and at each place or exhibit, instructors or students stationed there will briefly explain the experiment or machine in operation and answer any questions. Upon completion of this, the "Route Guide" will take his party to the next point, relating incidents and traditions and the nature of life at the Institute on the way.

In previous years, it has been found that apparatus in which "something moves" attracts the majority. In the "Testing Materials Laboratory," it is interesting to watch the reactions of the onlookers as a beam is fractured or a brick crushed under the pressure of almost imperceptibly moving loading machines. Several of these, one with a million pounds pressure capacity, will be in operation and various tests will be conducted for each group. In the engine laboratories, the numerous types of steam engines, pumps and the like, including the giant centrifugal pump throwing out twenty-two thousand gallons each minute, are on view. Experiments with the hydraulic and compressed air apparatus will be performed while one of the recent additions to the Institute's equipment, the large electric furnace, is included in this part. The size and complexity of the many engines in this group make an impressive view, and the relatively slight amount of noise when several are in operation arouses comment. Viewed from above, they resemble a tangled mass of pipes, blocks and wheels, but as the guide leads the way around them, one finds that remarkable system and order in the layout prevail.

In the expansive Machine Shops, the number and variety of contrivances for the working of metal at once startles those unacquainted with such shops. Here, too, the first sight gives an impression of crowding and chaos, but as one passes along, the nicety of arrangement becomes apparent. Auto-

(*Continued on page 24*)

THE CENTRAL LIBRARY READING-ROOM
Modeled upon the Pantheon at Rome.
The Institute Library, with over 200,000 volumes, including valuable scientific journals, is a great national center for technical research.

Technology's Contribution to Aviation

Showing how the Institute has willingly co-operated with the Government and with private individuals in testing and designing aircraft

By J. W. SULLIVAN
Graduate Student, Massachusetts Institute of Technology

IT is the prerogative of few scientific schools in the world to assume such an important place in industry as M. I. T. does in aviation. Starting in 1908 with the aeronautical researches of Professor Gaetano Lanza in his wind tunnel, the Massachusetts Institute of Technology has so progressed in the solution of aeronautical problems and in the training of aviators and aeronautical engineers that it continues among the leaders in the development of aviation.

In the solution of aeronautical problems the Institute has responded to the call of the Government in testing many types of aircraft ranging from swift scout planes and fast bombers to the leisurely moving rigid and semi-rigid airships. In addition, the Institute has co-operated with private individuals and with operating companies for the purposes of testing and designing commercial planes.

Since 1917 the models of new types of Army aeroplanes have been regularly submitted for exhaustive tests at the Institute. From such tests the performance, control and stability characteristics can be determined before the airplane is built. By this contribution alone, Technology has maintained a commanding position in the development of aviation.

In 1913 under the direction of Commander (then Lieutenant) Jerome C. Hunsaker, U. S. N., a second and larger wind tunnel was constructed which operated continuously for seven years. Although wind tunnels had been used for short periods previously, this is the oldest aerodynamical laboratory in the United States as regards continuous service. Since 1920 two new wind tunnels have been installed to enable the Institute to continue its researches.

The Government, however, has not confined its activities with the Institute to heavier-than-air aircraft. As a member of the sub-committee to consider the design of the Shenandoah (ZR-1) Professor William Hovgaard was appointed by the National Advisory Committee for Aeronautics to examine into the strength of this rigid airship, especially to pass upon the method of stress calculations and assumptions as to loading used in design. Subsequent experience has shown that the Shenandoah was satisfactory as to strength.

Because of the complexity and intricacy of the construction of airships of the Shenandoah type, many stresses are mathematically indeterminate and for this reason mathematical calculations alone are insufficient to solve the problem of the analysis and distribution of the loads to which the various girders and frame members are subjected. In seeking a satisfactory solution of the problem the Bureau of Aeronautics of the Navy Department asked Technology for co-operation. On the part of the Institute, Dr. Paul Heymans, Assistant Professor of Theoretical Physics, responded with the photoelastic method of determining stresses in all parts of the airship.

A celluloid model of the Shenandoah was made under his direction and tests were so successfully carried out that the stresses in the model could be subsequently determined to within five per cent of their actual value.

The Institute's contribution of a photoelastic method applied to rigid-airship research is noteworthy. The photoelastic laboratory of no other institution, university or research organization in this country was equipped to perform the delicate and detailed research involved in the investigation of the Shenandoah problem.

Although the construction of the Shenandoah is now a part of aeronautical history, the Institute continues to contribute to the development of aviation. Professor Hovgaard is now examining the design of the RS-1, the new semi-rigid airship which is being built by the Goodyear Company for the Army. As an immediate contribution, he is engaged in carrying out experiments with models of the RS-1. This type of aircraft is unusual in that it combines a rigid keel with an elastic bag.

The object of this investigation is to study the co-operation between the keel and the gas bag. It is hoped by this study to predict the strength of the ship especially as regards the co-operation between the keel and the bag.

In maintaining its position in the development of aviation, the Institute has included even aeroplane carriers in the scope of its researches and investigations. The problem of elevating planes from the hold to the flying deck, of equipping the carrier ships with guns for defense, and of accommodating smoke stacks in such a manner as to free the flying deck of obstruction, all as concern the distribution of stresses, have been studied by Institute experts.

The Lexington and the Saratoga, built last year and now in actual service, are two aeroplane carriers in whose design Institute experts figured prominently.

To meet the increasing demand upon its testing equipment, the Institute has installed eight electric dynamometers which will accommodate engines from fifty to six hundred horsepower, the six hundred horse-power dynamometer being the largest ever constructed. It is planned to go

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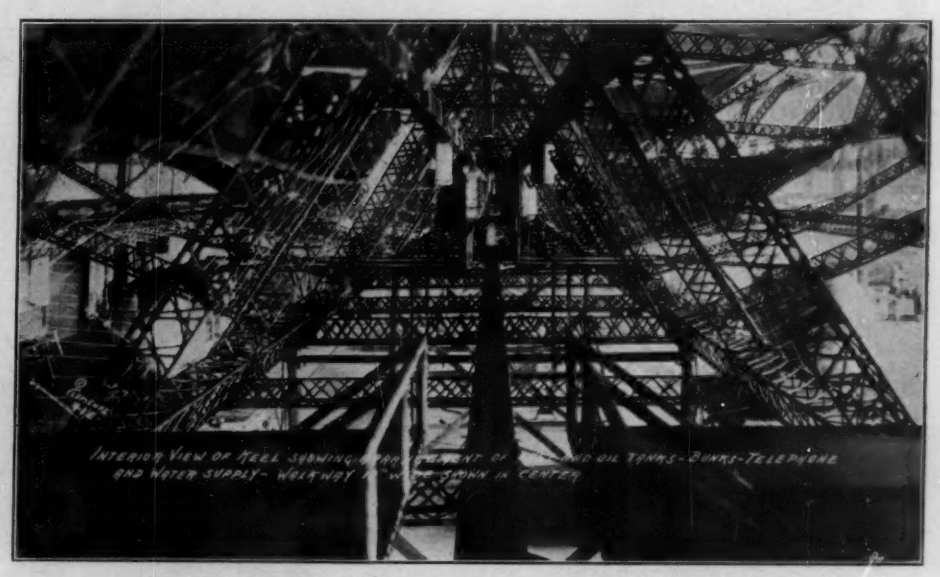

INTERIOR VIEW OF KEEL OF SHENANDOAH
The fuel and oil tanks can be seen in the center above the walkway. Four of the bunks appear in the foreground.

X-Ray Analysis

The application of this comparatively new discovery to engineering problems

By J. T. Norton, '18

Research Assistant, Department of Physics, Massachusetts Institute of Technology

FOR a long time the engineer who designed machines or structures concerned himself mainly with the actual breaking strength of the materials used, and the simple tension or crushing tests furnished about all of the available information. Gradually consideration of the elastic limit and yield point became available, and were found to be necessary in selecting suitable materials and designs, and more recently and in rapid succession have come the determination of hardness, the consideration of micro-structure, as well as a vast amount of material relating to the chemical composition of the metals used. In general the value of technical research in handling the problems that confront the engineer has been realized more and more, and one after another methods of investigation have been devised, and new tests and instruments invented, so that the engineer may have considerable knowledge of the materials with which he has to work.

The X-ray is one of the newest tools which has been adapted to the examination of the materials of engineering. The knowledge of the X-radiation itself is fairly recent, its discovery dating back less than thirty years. The science of what might be called "X-ray materiology" or industrial radiology is much more recent, and its possibilities are only beginning to be appreciated by the engineer and the technical man.

It will interest Tech men to recall that the earliest use of X-rays for medical diagnosis was in the Physical Laboratory of the Institute, and that one of the most important of X-ray instruments, the Coolidge tube, was the invention of Dr. W. D. Coolidge, Tech '96, now of the research staff of the General Electric Company at Schenectady, New York.

There are two general ways in which the X-ray may be employed, one often called radiography depending upon the very great penetrating power of the rays, and the other which may be referred to as crystal analysis, depends upon the interesting interaction of X-rays and crystals.

Radiography is the process of employing this very penetrating radiation to make visible the gross interior structure of objects which are opaque to ordinary light. This process was first developed by workers in the medical field. It was discovered that if the hand or other part of the body was placed in the X-ray beam, the skin and flesh was quite transparent, but the bones were opaque and showed very plainly when a suitable device for making the X-rays visible was employed. The image obtained was really a shadowgraph of the object which could be seen on a fluorescent screen or recorded on a photographic plate. If the object is of a homogeneous material, the different densities of the shadows produced indicate different thicknesses of material. If, on the other hand, the object is composed of different materials, the dense shadows are formed by the materials which have high densities. Thus the shadow cast by a piece of iron would be much denser than that of a piece of aluminum if the same thickness and the same radiation were employed.

The development of the X-ray tube and apparatus for driving it, together with the photographic plate have made it possible to extend the usefulness to materials which are much more opaque than the human body. The examination of metal castings and forgings is now readily accomplished. It is possible to examine a steel casting about 3½ inches in thickness and if it contains imperfections in the shape of blow holes, pipes, sand pockets, shrinkage cracks and the like, they will be visible, and their size and location readily shown. The importance of this added safeguard for materials used in the construction of air craft and automobiles is evident. In special machines such as racing cars every part should be examined, and this procedure would possibly prevent a broken crankshaft or steering knuckle with results which are likely to be disastrous. Again, in the case of a large and complicated casting on which the machine work is very expensive, the uncovering of a small blow hole during machining may show it to be absolutely worthless but only after the expenditure of much labor. The X-ray examination would cause the detection of defects without loss from useless labor. The usefulness of this method of examination is not, of course, limited to castings and forgings. Built-up or fabricated articles whose internal construction cannot be seen from the exterior, may be carefully examined without chance of derangement or injury.

For rather transparent materials, such as wood and fibre, a fluoroscopic screen may be used for visual examination. The screen is a card covered with a layer of a finely divided crystalline material which fluoresces or gives off visible light when X-radiation falls upon it. The brightness of the visible

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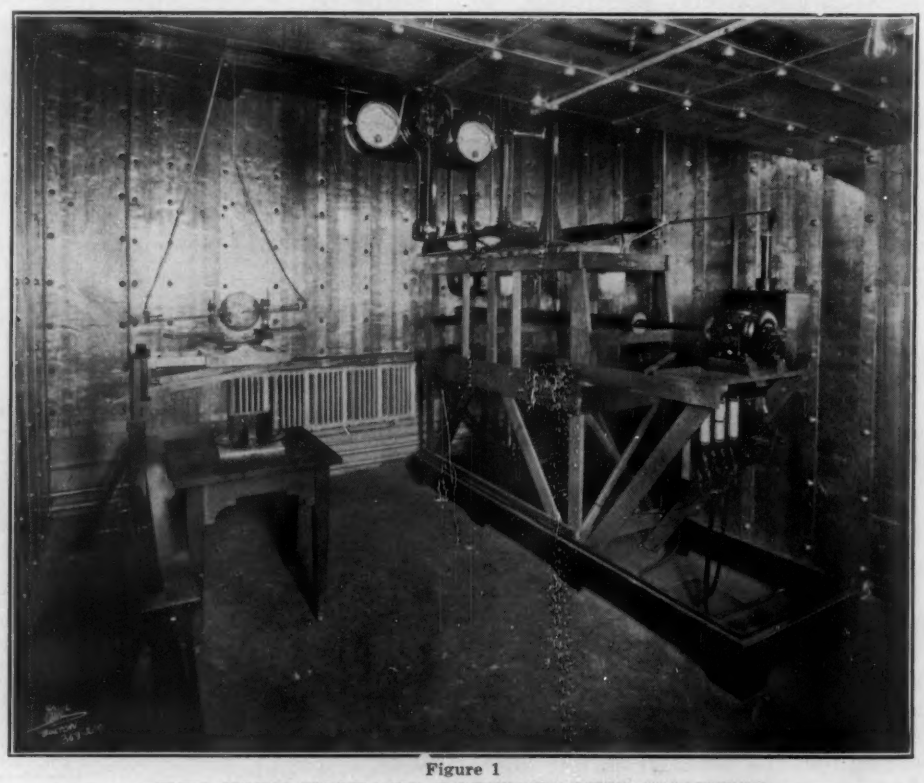


Figure 1

THE HIGH VOLTAGE RADIOGRAPHIC MACHINE

The room in which the machine is placed, except for the floor, is lined with sheet lead one-quarter of an inch thick and weighing about 8 tons. The machine is entirely controlled from outside the room.

Hastening Plant Growth with Artificial Sunlight

A new electrical development using electric incandescent lamps, which has proven of commercial importance

By E. P. Roll, Jr., '23
Illumination Bureau, Westinghouse Lamp Co.

SINCE the beginning of time, one of man's most important activities has been the procurement of food to support his own life. The plant kingdom has offered him his most free supply. There the true raw materials for life's nourishment are gathered and combined by simple and complex organic chemical reactions into carbo-hydrates. This food product going through the metabolism of the human body, gives man the energy to do those wonders once thought unattainable.

Realizing that for future generations, and with the present growth of population, one great problem facing us all is the one of securing more food rapidly. Westinghouse engineers set to work on the study of hastening plant growth by supplementing daylight with extra hours of artificial illumination from electric incandescent, or Mazda C lamps. In co-operation with Professor Hugh Findlay of Columbia University, the preliminary experiments were carried out at Columbia in the spring of 1923. The electrical equipment consisted of deep bowl reflectors equipped with 500-watt lamps spaced on 15-inch centers. Sunlight was supplemented with five hours of artificial illumination each night. The intensity of light used was above 500 foot-candles or about 50 times the illumination found in our well lighted commercial offices. The results proved satisfactory and some of the conclusions drawn were:

1—The use of Mazda C lamps have a beneficial effect on the growth of flowering plants started from cuttings.

2—The use of artificial illumination plus sunlight forces a more rapid growth of seedlings.

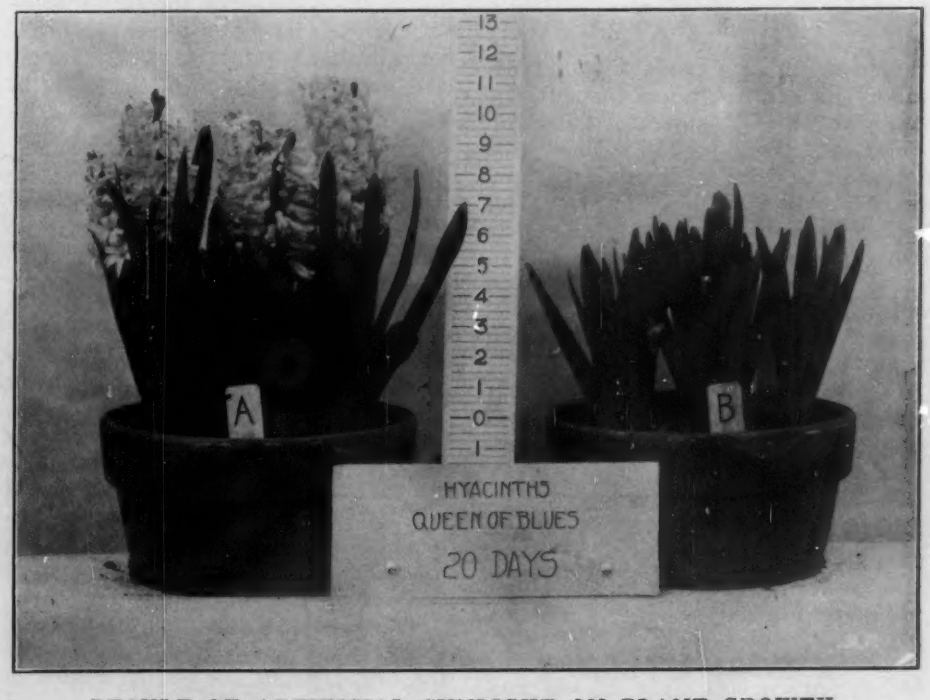
Further experiments were carried on in co-operation with the Public Service Electric Company of New Jersey and the Peter Henderson Company in their Jersey City greenhouse. Bulbous plants were put on the propagating bench under an illumination of approximately 500 foot-candles, the intensity being measured by a Macbeth Illuminometer. The increase of growth under the added artificial light can be readily seen in the illustration.

The results obtained were gratifying and seemed to prove that artificial illumination held commercial advantages for the grower of seasonal plants. For example, a rose grower of Scarborough-on-Hudson, New York, cuts close to two million roses each year. Allowing six to seven weeks for a bud to bloom, his plants are pinched back to produce their big crops during the holiday seasons. If during the scheduled growth, two or more weeks of dark and cloudy weather are encountered, then the roses do not come in on time and thousands of dollars are lost. No amount of fertilizer, heat, or moisture will take the place of the required light to cause the photosynthesis in the green plant leaves.

The use of artificial illumination is not confined solely to the grower of the flowering plants. Tomato growers in the Canadian Northwest have been extremely successful in using artificial light stimulus. With 500-watt Mazda C lamps, equipped with deep bowl reflectors on two-foot centers, an increase in weight of 15 per cent was obtained, the fruit being picked one week earlier. Cucumber raisers in Ohio, with vast areas under glass, are now considering the advisability of hastening their crop and insuring the early delivery of their product to market.

Following the preliminary research of the U. S. Department of Agriculture, work was done on the effect of colored light on plant growth. Compartments 3′ x 5′ x 4′ were constructed, and color screens furnished by the Corning Glass Works for transmitting the wave lengths of light used. An equal intensity of illumination of about 360 foot-candles was obtained in all compartments. The results seemed to substantiate in an experimental way the predictions of the affect of visible radiations on plant life. The necessity of the longer wave lengths of lower frequency for plant growth is convincingly shown in the illustration. This does not mean the shorter wave lengths are harmful. These higher frequency waves may even be converted to lower frequency through the fluorescence of the plant leaves. The plants under the yellow and clear lamps, both rich in the red-yellow end of the spectrum, showed a much more rapid and healthy growth.

With the various new ways of controlling plant growth, future generations will have little reason to worry about their food supply. Besides the use of artificial sunlight, experiments are now being carried on by the Boyce-Thompson Institute in Yonkers, N. Y., with apparatus which gives means of accurate control of all factors affecting plant growth. That is, temperature, humidity, CO_2 content of the air, and periods of light stimulation. The Westinghouse experiments are being extended to a study of the action of X-ray radiations on germination, and all such studies, leading as they do to civilization's advancement, give added encouragement to practical applications of pure science.



RESULT OF ARTIFICIAL SUNLIGHT ON PLANT GROWTH
A—Sunlight plus artificial sunlight. B—Sunlight only

Ceramic Engineering

An enormously important field which has received but scant attention in American technical schools

By A. F. GREAVES-WALKER
Professor of Ceramic Engineering, North Carolina State College

FROM prehistoric times ceramic wares have been essential to man's welfare. He builded his abodes, fashioned his utensils, expressed his art and recorded his achievements in clay and glass. With each advance and retreat of civilization, ceramics advanced and retarded. With changes in local ideals and customs, ceramics changed, but the art of ceramics and ceramics as the medium of art expression was at no time lost; each advance was permanent. Utility and art were never divorced. With the discovery that clay could be fashioned and its form made permanent by firing, clay vessels were home utensils and home utensils became home decorations. Glass and cement were first formed by chance, but it was not by chance that glass making and the use of cement parallels the history of civilization. Ceramic wares have in all past ages been essential to man's material and spiritual welfare and are more essential to-day than ever before.

What is ceramics and what is ceramic engineering? One hears this question constantly, and naturally, for up to a comparatively few years ago the word "ceramics" or "keramics," to those who had ever heard it, meant artistic pottery, and the term "ceramic engineering" was coined less than thirty years ago after the birth of the world's first Department of Ceramic Engineering at Ohio State University.

The word "ceramics" is derived from the Greek word "keramos," which was used by them to define "burnt stuff," or a product made from earthy material obtained through the action of high temperature or fire. American usage has broadened this definition to cover those products made by the action of heat on raw materials, most of which are of an earthy nature, while of the constituents of these materials the chemical element silicon, together with its oxide and compounds, occupies a predominant position.

Under this definition we may enumerate among the products of the ceramic industries the following:

1. Clay Products

All kinds of burned clay products, such as stoneware, earthenware, brick, tile, sewer pipe, terra cotta, china, porcelain, etc.

2. Cements and Limes

Cementing materials, such as Portland cement, dental cements, lime, plaster, and a variety of magnesia and gypsum products which have the property of "setting."

3. Glass

All varieties of glass and glassware, including quartz glass, glazed enamels, and artificial precious stones.

4. Enameled Metals

Enameled metal products, where the enamel itself is a ceramic material applied to the metal at high temperatures.

5. Refractories

Refractory articles or materials either wholly or partially composed of clay, silica, alumina, magnesia, chrome or electric furnace products.

6. Abrasives

Abrasive materials such as carborundum, alundum, emery, garnet and products manufactured from them.

7. Insulating Materials

Electrical and thermal insulating products.

Little need be said about the importance of these products to the human race and their relation to our national wealth. One cannot look in any direction in the home or on the street without the eye resting on a ceramic product. The dishes on the table, the enameled ware in the kitchen, the glass in the windows and electric bulbs, the bathroom fixtures, the brick and plaster in the homes and, on the street, the concrete sidewalks and roads, the electric insulators and street signs. Wherever a factory chimney is seen, refractories are used in the furnace at its base; the locomotives and steamships must have refractory boiler linings; in fact, industry and transportation without ceramic products would come to a standstill. Large cities with their concentrated dwellers are only possible through the modern sanitary sewer systems and it was not until clay sewer pipe was first introduced into Europe that the plagues that decimated the large cities were eliminated.

Taken as a whole, the products of the ceramic industries rank among the first four in the United States in money value and the industries (not including the railroads) rank second in point of consumption of fuel. And they are constantly growing. As our timber reserves are being depleted twice as fast as they are being replaced, it is estimated by authorities that in twenty years wood in construction will be limited to inside trim on account of its price. Clay products and cement must inevitably replace lumber in construction and the next twenty years should see such an expansion in the use of these products as to dwarf anything in the past, remarkable as the expansion has been during the past thirty years.

Thirty years ago Brigadier-General Edward Orton, Jr., D.Sc., then on the Engineering Faculty of Ohio State University, saw what those in the ceramic industries had failed to realize—that the formation of silicates from complex minerals at high temperatures was in reality a branch of the science of physical chemistry. It was his idea that the manufacture of silicate products could be technically controlled and with but little encouragement from the industries he wished to aid he began giving courses in what today would be classified as Ceramic Chemistry. Within a few years this new technical field became Ceramic Engineering—the application of science to the ceramic or silicate industries. Five years later, in 1900, the second Department of Ceramics was established at Alfred University, Alfred, N. Y., known as the New York State School of Clayworking and Ceramics. This was followed by the establishment of a department at Rutgers, Illinois, Iowa State, University of Washington, North Carolina State, Georgia Tech and Penn State. In 1921, the first Canadian department was established at the University of Saskatchewan. This year three of these departments have one hundred or more students.

The hundreds of graduates these departments have turned out are filling positions in every branch of ceramics and although more trained men are available each year, the demand far exceeds the supply. Last June it was estimated by one department head that there were five positions offered for each graduate available.

The changes and advancement that the ceramic engineer has brought to pass in the industries are beyond estimation. One only needs to look back at the bathrooms; the brick and terra cotta in the buildings; the highways and pavements; the electric insula-

(*Continued on page 36*)

Recent Books

This department conducted in co-operation with the Technology library

AERONAUTICS

The History of Aeronautics in Great Britain from the Earliest Times to the Latter Half of the Nineteenth Century. By J. E. Hodgson: Oxford University Press, London, 1924.

The students and faculty of the Massachusetts Institute of Technology are not unfamiliar with the importance of history in the study of science. Interesting in itself, the story of past efforts and past achievements has a very real place in any curriculum, for the future is reflected in the light of ages gone. The installation of the Clark and Taylor collections in their new home have indeed served within the past few months to emphasize the importance which the history of shipbuilding possesses in the current practice of naval architecture. Just as the naval architect finds inspiration in the long story that runs from the galleys of ancient Phoenicia to the Lexington and Saratoga, so also to the airplane designer the reading of aeronautical history may easily be useful and must always be interesting.

The Clark collection takes the art of shipbuilding far back in history, but neither that nor any account of the development of seacraft goes back far enough to reach the time when men doubted the possibility of building a boat. Never was the study of marine engineering, as was that of aeronautics for many generations, considered an *ipso facto* proof of lunacy. One's memory need not be very long to recall the time when all would-be flyers were dubbed Darius Greens, and when their activities were adjuged too silly even to make subject for good jest.

The burdens carried by the pioneers in the aeronautical art were great, and the history of the subject is a story of their patient efforts and of an enthusiasm which triumphed over all obstacles, and which remains an unfailing inspiration to their successors. They were of many sorts, those pioneers, some of them crack-brained visionaries, while others were men already eminent in science and jeopardizing in what the world thought madness, a reputation already hardly won. Mr. Hodgson has given an exhaustive account of their trials and of their gradual advance towards final triumph, an account which gives evidence of extended and painstaking research. The book covers more than 2,000 years in time. It begins with Bladud, that Bladud who reigned over Britain in the ninth century before the Christian era, and of whom an ancient chronicler states with apocalyptic brevity:

"As from a Towre he sought to scale
the Sky,
He brake his necke because he soar'd
too high."

and it ends with William Samuel Henson, the boldness of whose vision entitled him to a high place despite the somewhat doubtful methods by which he attempted to secure capital for the exploitation of his ideas. When Henson ceased his active work at the point where Mr. Hodgson lays down his pen, the jeers of the crowd were as loud as ever, but to the scientist who gave the matter serious consideration it was already apparent that the attainment of human flight was nearly within reach.

Not the least among the merits of Mr. Hodgson's book is that it should be of some assistance in establishing in its proper place the fame of Sir George Cayley, the father of British aeronautics, yet so neglected by his own countrymen that his name does not appear in the dictionary of national biography. Cayley was a man whose misfortune it was to be born 50 years ahead of his time and to allow his imagination to carry him 50 years beyond his contemporaries. His researches form a landmark in the history of aeronautics, and the 20 pages that Mr. Hodgson devotes to them are worthy of the attention of anyone who feels even the slightest interest in the chain of events that has led from King Bladud to the ZR-3 and the Douglas World Cruiser.

Edward P. Warner, '17.

CHEMISTRY

Aniline and Its Derivatives. By P. H. Groggins. D. Van Nostrand Co., New York, 1924. Cloth 6 x 9 ins., 256 p., illustrations, diagrams, tables, $4.00.

This book, just published, gives a very good insight into the various methods of manufacture of aniline, describing in detail the complete processes now in use, as well as the processes which were formerly used, giving cost data and the difficulty and advantages of each process. It also covers the manufacture and preparation of all the direct materials which enter into the production of aniline, such as nitro-benzene and iron. The book contains a very good chapter upon the uses and properties of some of the most important derivatives of aniline, such as the azo compounds and various important amines and quinones. The book is very well arranged and has numerous drawings and illustrations to accompany the text, which gives a good insight into the production and uses of aniline and should be of much use to the student of chemistry and chemical engineering, and to practicing chemists.

The Elements of Colloidal Chemistry. By Herbert Freundlich; translated by George Barger. New York: E. P. Dutton, 1924. 202 p.

A non-mathematical treatment covering the Brownian Movement, Colloidal-Disperse Systems, Sols, Gels, Mists, Foams, etc. It is particularly adapted for use by the non-technical reader and would be a handy addition to the reference library.

GEOLOGY

The Earth: Its Origin, History and Physical Constitution. By Harold Jeffreys. Cambridge, Eng.: University Press, 1924. 278 p.

Author, a Fellow and lecturer of St. John's College, discusses the theories of the main problems of geophysics, and discusses their interrelations. Quantitative comparison of theory with fact being the main object of the book, the treatment is mainly mathematical.

MATHEMATICS

History of Mathematics. Vol. 1: General Survey of the History of Elementary Mathematics. By David Eugene Smith. Boston: Ginn & Co., 1924. 596 p.

Prof. Smith, head of the mathematics department at Teachers' College, New York, has written this textbook for those who are beginning the study of the subject. The present volume considers the growth of mathematics by chronological periods and the progress and achievements of various races; the second and last volume will discuss the development of the leading branches of mathematics. The work is accompanied by abundant portraits, facsimiles and illustrations.

Cugle's Practical Navigation. By C. H. Cugle. New York: E. P. Dutton, 1924. 351 p.

Written to supplement the author's earlier works on navigation and including the changes in the Nautical Almanac for 1925, this volume should be extremely useful to the student of navigation.

The Engineering Field

Excerpts from the leading professional and trade journals

Successful Rubber Bearings. Questions have been asked of T. E. N. concerning this new development in bearings — Olivite Rubber — particularly with reference to possible application to other than marine use. Investigation was made.

The bearings are made up of an outer shell of metal lined with a tough rubber compound known as "Olivite," which has spiral grooves cut into its surface to allow the passage of the lubricant, which is water. The advantages of the bearing over metal or lignum vitae are based upon the fact that the coefficient of friction between the wet Olivite and a metal surface is less than that between oiled babbit or lignum vitae and metal; abrasive material of any nature which gets caught between the two surfaces impresses into the rubber, is rolled on into a groove and washed out by the stream of water, having in no way scored or injured shaft or bearings, and pounding and vibration of the shaft in the bearing is prevented, owing to the incompressibility combined with resiliency of the rubber.

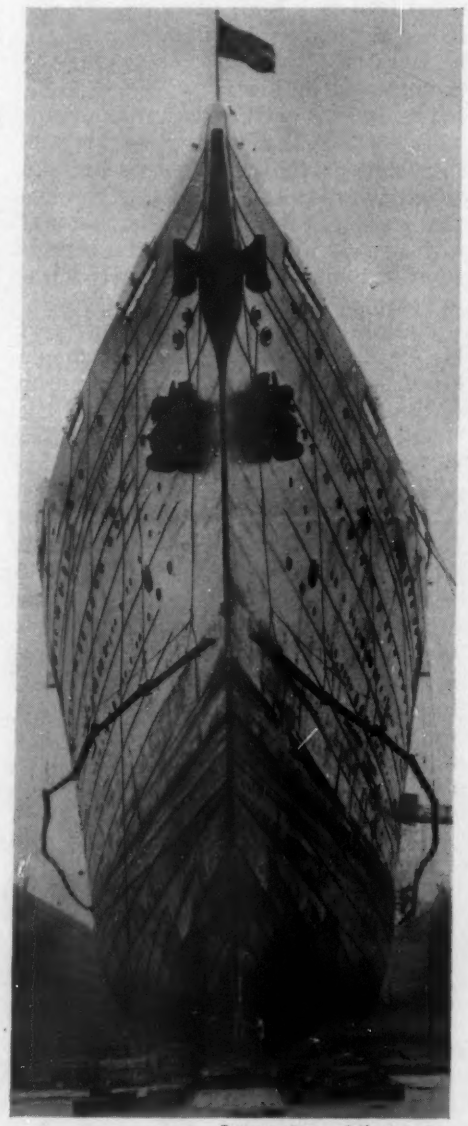
Shaft deflection is negligible; a 9¾-inch propeller shaft bearing on the Standard Oil Barge *J. H. Senior* carrying a total weight of 5,500 pounds, showed a deflection of only eleven-thousandths of an inch at the end of a bearing 33 inches in length.

Numerous installations on vessels operating in the most adverse conditions, sand and silt-filled water, show only one-eighth the wear of lignum vitae bearings previously used, and on the Colorado River, where the water is so dirty it can not be used even for cooling the motors, no bearing replacement has been necessary for over two years.

Several manufacturers of pumps handling sand, of hydraulic turbines of the reaction and impulse type for the generation of power, and of other pumping and turbine machines, report remarkable results obtained by the use of these bearings. They are used at speeds up to 2,800 r.p.m. The bearing also finds an application in pumps handling acids, since the rubber is so peculiarly resistant to corrosion by them that its lubricant is the acid being handled.

Interesting application has been made of this Olivite rubber in the manufacture of wearing or sealing rings on hydraulic machines. Curves taken on tests of a four-inch Volute centrifugal pump operating at 1,750 r.p.m. under sandy conditions show ten to fifteen per cent increase in efficiency with the use of these rings, and certainly they are much longer lived than metal rings under the same conditions.

Concerning further applications of the bearing, the manufacturer states that "Cutless Bearing application on an electric motor would be rather difficult to work out, particularly with regard to the lubrication of the bearing, for water as a lubricant is absolutely necessary."



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LEVIATHAN IN DRYDOCK

This unusual view of the Leviathan was made when it was in drydock at Boston recently for reconditioning. The four-bladed propellers were replaced by three-bladed units, the hull was scraped and repainted, the interior was cleaned and redecorated and a new ventilating system was installed.

Time does not seem to cause disintegration of the rubber, because the wet, dark atmosphere under which it operates is ideal for rubber and prolongs its life indefinitely.

Fireproofing of Structural Steel. In an address before the American Institute of Steel Construction, Mr. A. W. Sinnamon stated that contrary to the belief of many, structural steel does not lose strength exactly as the temperature increases. Within certain limits, indeed, both the ultimate strength and elastic limit of the steel is increased, provided that free expansion is allowed. Under such a condition of free expansion, the steel would have a strength sufficient to support its designed load at a temperature of 1,000° F., which is considerably in excess of that met with in ordinary fires. In practice, however, free expansion is rarely allowed for and a much lower limit must be maintained. Also the rate of expansion will vary with the height of the temperature, a matter of considerable importance when the sudden cooling effect of applied water is considered. In view of this, the following conclusions may be drawn as to the best methods of fireproofing: first, any heat that reaches a structural steel section in a building should be uniformly distributed over the entire area of the section. Second, the steel members should be free to expand when heat is applied or they should be so protected as to permit but a moderate increase in temperature.—*The Iron Age.*

Research of Metals at Extreme Temperatures. A joint research committee, representing the American Society for Testing Materials and the A. S. M. E., have been selected for a "Research on Properties of Metals at Extreme Temperatures." The objects to be accomplished by this committee are outlined as follows:

(1) "Accumulation of existing unpublished data covering satisfactory and unsatisfactory service in different fields of engineering of various metals under extreme temperatures.

(2) "The making of studies leading to standardization of the procedure for testing materials at high and low temperatures. These should preferably include studies of new comparative tests of metals by the principal methods now in use in various laboratories.

(3) "Outlining and fostering new research work in this field. The first and most important materials to be investigated are considered to be carbon and alloy steels, so-called 'heat-resisting' alloys consisting of various combinations of nickel, chromium, iron, tungsten, molybdenum, etc., and trimming materials (chiefly alloys of nickel and copper) for valves and equipment intended for high-temperature service in power stations, oil refineries, etc."—*Power.*

Railway Reconnaissance Surveys by Airplane. The first use of airplanes in railway location is reported from Canada. H. K. Wicksteed, location engineer, used this means to supplement the work of the field survey party during the reconnaissance of the proposed Abitibi Southern Railway in Quebec. The function of the seaplane used was to fly over the country in advance of the field party and by visual and photographic observation, obtain as much information as possible to aid in the selection of the best route. One of the most important objects of a location survey is the determination of the elevation of the hills and ridges and this is difficult to accomplish from the air in the comparatively short length of time available. Numerous oblique photographs and low flights over the surface of rivers, however, proved of value in this respect, the work of many days' strenuous canoeing being accomplished in a few hours. A seaplane was selected on account of the almost continuous chain of lakes in this region. —*Engineering News-Record.*

Listening to the Stars. To eliminate the "human factor" in making time observations and broadcasting time signals, General Gustave Ferrie and M. R. Jonanst have perfected a machine that makes the observations automatically.

It makes use of a photo-electric cell, containing potassium in vaccua, which allows the passage of an electric current when a beam of light falls upon it. This current is then amplified and sent out as a radio wave.

In using the apparatus, the photo-electric cell is placed at the end of a large astronomical telescope which has been focused upon a point along the star's path. When the star crosses the line of sight, its light causes the potassium to disintegrate and this, in turn, causes a current to flow, which broadcasts the radio time signal—*Scientific American.*

Experimental Oil Shale Retort. There has recently been developed at the Boulder, Colorado, field office of the Bureau of Mines, an experimental oil-shale retort that embodies a number of interesting features of design and construction. The apparatus is essentially an element of the Pumpherston retort so largely used in the Scottish oil-shale industry.

The material to be retorted is fed downward through the retort into the bottom of which superheated steam at a temperature of about 1,200° F. is admitted. The superheat is transferred from the steam to the material by undercurrent flow. Bins are so arranged at the top and bottom that the process can be made continuous and the feed mechanism can be adjusted to regulate flow. A heat recovery scheme has been provided for recovering the heat from the spent shale. —*Chemical and Metallurgical Engineering.*

Pile Driving Under Water. An application of a steam hammer to submarine pile driving at an unusual depth of water has been made in connection with the foundations of the Burnsick bridge across the Willamette River at Portland, Oregon. The water is 80 feet deep at the bridge site and the river bed consists of sand and coarse gravel. The method adopted was to rig a McKiernan-Terry sub-70 ft. long which telescoped into main leads 110 ft. in length mounted on a barge. Forty feet of the main leads were submerged in water and the telescopic leads carrying the hammer were extended down to the river bottom. Piles 40 to 50 ft. long were driven by the hammer, while entirely submerged, until their tips were about 10 ft. above river bottom.—*Engineering News Record.*

Magnesium Propeller Successfully Tested. The first flight with a single piece magnesium propeller was recently made at Curtiss Field, Garden City, New York. The tests were completely successful and were made on a J-1 Standard, equipped with a Curtiss C6 motor. Previous to these tests the propeller was given a ten-hour whirling test with 100 per cent overload (300 h.p.) and passed all requirements. This alloy is 25 per cent lighter than duralumin. Such a propeller can be made to achieve all the benefits to be derived from the superiority of metal construction and need weigh no more than its wooden prototype for a similar machine.—*Aviation.*

Micarta Propellers. Cotton-duck fabric impregnated with resin has been found to give greater tensile strength and far greater crushing strength edgewise than wood for the same weight.

The cotton-duck is prepared in thick rolls, cut to shape in laminations about half an inch thick, placed in carefully fitted phosphor-bronze mold and subjected to heat by steam and to tremendous hydraulic pressure. Micarta propellers, once the mold is there, can be made more quickly and accurately than wooden propellers, and due to the greater strength of the material, thinner, more efficient and lighter blades can be used.—*N. A. C. A. through the Scientific American.*

Bureau of Mines Electric Furnace Equipment Destroyed. All of the electric furnace equipment of the Bureau of Mines was completely destroyed in the fire which recently burned the old Mines Building at the University of Washington. It is expected that Congress will provide at this session for the replacement of the transformers, the switchboard and the other electric equipment which is so essential to the work assigned to the Seattle experiment station.—*Chemical and Metallurgical Engineering.*

Ford Co. Establishes Engineering Laboratory. What is said to be the finest engineering laboratory in the country is being completed by the Ford Motor Company at Dearborn, Michigan. It is designed for chemical, metallurgical and affiliated industrial research and experiments. The mechanical installation consists of complete equipment for the construction of an entire automobile, with chemical research apparatus, physical test machines, equipment for metallurgical research and investigations, drafting room facilities, etc. The building will also contain a comprehensive reference library.—*Chemical and Metallurgical Engineering.*

Girder Tests. Tests to determine the possibility of getting greater strength for the same weight in airship girders are being undertaken by the Bureau of Standards. The bureau finds that it is possible in the best duralumin girders of today to apply a load of only 20,000 pounds per square inch of metal whereas the metal itself will not yield under compressive stresses of over 30,000 pounds per square inch of metal. Better design, it is thought, may result in the strength of the girder approaching more closely the strength of the metal. However, since it is practically impossible to correctly calculate the strength of such girders, it will be necessary to make girders and girder parts and test them for strength.—*U. S. Standards.*

Baldwin Diesel-Electric Locomotive. The Baldwin Locomotive Boiler Works are reported to be experimenting with a new type of Diesel-electric locomotive in which it is hoped to use the cheapest grade of crude oil. The locomotive is not intended for general use but is being constructed to meet the requirements of special service especially where, for long distances, the railroad passes through country without water or where oil is the only fuel obtainable. It is expected to be ready for trial this month.—*Power.*

Professional Notes

Activities of the Undergraduate Engineering Societies

CHEMICAL ENGINEERING SOCIETY

During the last term the Society tried a new innovation in the line of smokers. In place of the conventional evening smoker a so-called "luncheon-smoker." The experiment was a success as was shown by the large attendance.

At the first of these luncheons, Doctor Megus, Director of the Research Laboratories of the Massachusetts General Hospital spoke on the biological and physiological aspects and applications of chemistry. He also outlined some of the work being carried on in the laboratory.

Another of these luncheons was held a few weeks later, at which Doctor Herman Lythgoe was the speaker. Doctor Lythgoe is a member of the Massachusetts Pure Food Commission. He spoke of the work of the commission, which includes not only the analysis of the various foods, and since Prohibition the analysis of all confiscated liquor, but also the legal prosecution of the case, providing the analysis shows that the packer did not live up to the law when manufacturing his product. He cited several instances which showed that the Commission was doing good work in keeping adulterated foods from the market.

CORPORATION

The annual spring tour of the Corporation was made during the vacation; the itinerary was as follows: The group left the North Station in a private car, which they had chartered on March 19, and proceeded to Springfield where they inspected the Coach Works Plant of the Rolls-Royce Automobile. From thence they proceeded to New York City, where two days were spent; one in a visit to the department store of Abraham and Straus and the New York Stock Exchange and the other in a visit to the Babcock and Wilcox at Bayonne, New Jersey.

The Rolls-Royce Plant in Springfield is an assembly shop for the cars, which are manufactured in Europe for the American market. Here the members of the party were given an insight into the reason for the expensiveness of that make of car. In some instances the castings and forgings used in the manufacture of cars were machined down to thirty or forty percent of their original size in the finishing process preliminary to being assembled on the car.

At the Abraham and Straus Company's store the party was shown through the store and the technicalities of the management of the store were explained by the officials in charge of the various departments. After luncheon, which was tendered them by the Company, the whole party went over to the New York Stock Exchange. They were shown through the 'Change and had the operation of it explained to them.

The next day the party went out to Bayonne, New Jersey, and went through the Babcock and Wilcox Plant. The construction of boilers and accessories was shown them from foundry to finished product. This Company is one of the largest producers of boilers and accessories, so those who availed themselves of this opportunity to visit the plant saw what could be done with large scale production.

This inspection trip closed one of the most successful tours ever undertaken by the Corporation.

MECHANICAL ENGINEERING SOCIETY

At the smoker in the latter part of February, Professor Allen of Worcester Polytechnical Institute spoke to the Society on the "Uses and Abuses of Gasoline." His talk was highly amusing as well as instructive and he performed many simple but effective experiments to illustrate and drive home his points. With an old coffee can and a spark-plug he illustrated the action of the vaporized gas in the cylinder of a gas engine.

He did not confine his attention solely to gasoline but took up kerosene as well. Merely to show how "safe" gasoline was, he soaked a cigar in gasoline, lighted it and inhaled the vapor and igniting it as he expelled it from his mouth, giving an effective illustration of one of the fire-breathing demons of Tartarus. The up-shot of his whole talk was that gasoline and kerosene, when handled with proper precautions, were as safe as water.

CIVIL ENGINEERING SOCIETY

The first smoker of this year's program was held in November. Professor Spofford, head of the Department, gave an illustrated lecture on "Bridges, Ancient and Modern," which covered the art of bridge-building from those of earliest record down to our modern structures of steel and reinforced concrete. The outstanding feature of the meeting was a group of lantern-slides, made from actual photographs of bridges of all kinds and descriptions, which were taken by Professor Spofford during an extensive trip through England and the Continent.

Mr. O. C. Merrill '12, Chief of the Federal Water Power Commission, spoke to the Society in January on the work of the Commission and its aims and purposes. This Commission has jurisdiction over the granting of licenses for the construction of dams, bridge-piers, or power projects where any navigable river or stream on public lands is involved. The effect of any such structure on the potential power resources of a stream is as carefully studied before the license is granted, the criterion being that the ends attained must be in accord with the best possible development of the power resources of the stream.

The lecture was supplemented by a lively talk by Mr. G. H. Malthus who gave a few reminiscences concerning the infancy of power engineering. He gave a graphic description of an early power transmission line, which looked ordinarily enough in the daylight but which presented a lurid spectacle at night.

The Society has a standing invitation from the Boston Society of Civil Engineers to attend the monthly meetings of the Designers' Section. These meetings are devoted to the presentation of papers by the members; the papers are then discussed by members from the floor. The discussions are of immense value to members, because it is from such discussions that the student or the recent graduate can get valuable pointers on how to act, should any similar circumstances arise in his practice. Papers were presented at the February meeting, which covered the Neponset Bridge construction, Design of Superposed Chimney's for Power Houses, and Structural Features of Hydro-Electric Development. The discussion of each of these papers brought the difficulties met with in practice and the remedy applied in each case under discussion. The Neponset Bridge offered fruitful ground for discussion as most of the work was done under winter conditions.

In February, the Society was addressed by Mr. C. H. Pierce, chief of the New England District of the U. S. Geological Survey. His subject was "The Measurement of Flow in Natural Channels, with specific Reference to Winter Work in New Eng-

(*Continued on page 38*)

Stake out your claim in this field

ONE field where there is still undeveloped territory, still room for pioneers, is the electrical industry. This will be encouraging news to the man who thinks he was born too late.

If your aptitude is technical, there are years of usefulness ahead of you in helping to design, construct and operate public utility lines. And too, fast-growing markets for electrical apparatus call for more and more college-trained men in the manufacturing end of this industry.

Or if your interests are along commercial lines, there is a broad opportunity for you here in the various departments of purchasing, accounting, distributing, selling and advertising

Published in the interest of Electrical Development by an Institution that will be helped by whatever helps the Industry.

Western Electric Company

Since 1869 makers and distributors of electrical equipment

Number 47 of a series

The Better Condenser Tube

(*Continued from page 11*)

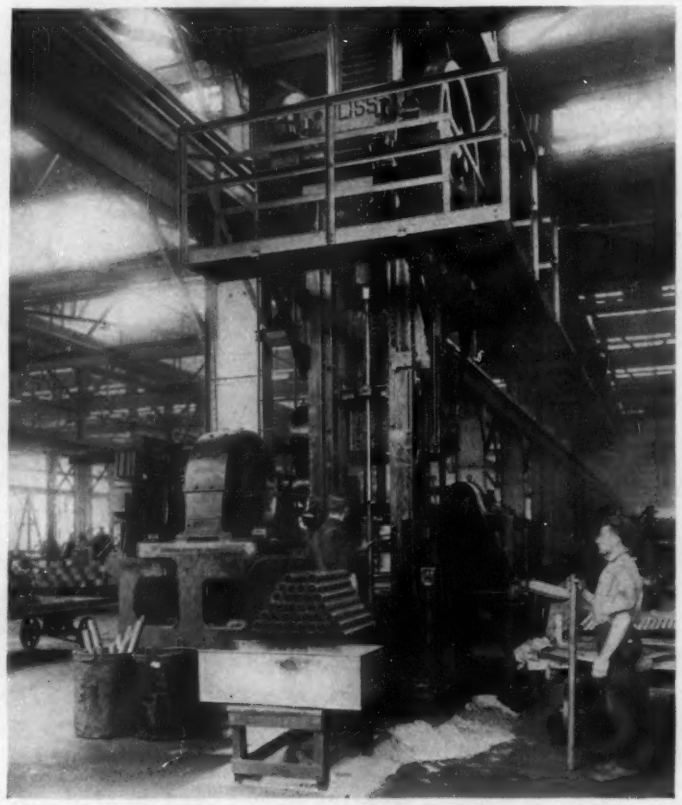
Before annealing them to restore equilibrium to the crystal structure, they are inspected—the fifth time. Large pans holding hundreds of cups are annealed and treated as were the bars. After each press has done its part, the cups must be heat treated.

The third press produces a cup about ten inches long by five inches diameter; the fourth, one about 17 inches long by 3 3/4 inches diameter; the fifth press draws a cup about 31 inches long by 2 3/4 inches diameter; while the sixth press extends the length to 54 inches and leaves the diameter only a little over two inches. After annealing, the closed end is squeezed ("pointing," it is called) so that it will pass six inches into the die of the draw bench, and permit the jaws of the carriage to grip it tightly. Before drawing it through, the pointed cap will be passed over a steel mandrel mounted on a long rod fastened at the rear end of the bench. Being thoroughly lubricated inside and out, the tube passes over the mandrel and through the die. Here it is lengthened, its diameter reduced and the thickness of wall reduced to desired dimensions. At the next step it is annealed. If the tube is to be a small one, it must be re-drawn several times—always after heat treatment.

Final operations are those of cutting to desired lengths, removing burrs, and inspecting. This final inspection includes testing every tube with water at 1000 pounds and air at 100 pounds pressure. Two tubes from each lot of 600 must be given the expanding test (driving a pin, having a taper of 1½ inches per foot, to enlarge the internal diameter 26 per cent), also hammering flat the six-inch ends cut from test pieces. Two must be examined microscopically and photographed to show grain size. Their length must be not more than 1-16 inch greater at 6 deg. F., but if shorter than that specified, they cannot pass.

The diameter cannot vary from that specified by more than 3-1000 inch. Thickness of wall must not be less, at its thinnest point, than that specified. An excess of five per cent is allowed on weight, calculated on a basis of .308 pounds per cubic inch of metal. The test to determine whether or not all strains have been removed, is that of immersing a six-inch piece in a solution of mercurous nitrate for 15 minutes. If there are strains the test piece will open up as shown in the photograph. If they do not so split, the tube maker knows that there is no danger of "season cracking."

Let us now take the billets indicated above and sort them according to the laboratory's report. The accepted ones will pass to a saw to have the gate end removed and be cut at the middle.



SIXTH PRESS

This press draws the 31 inch tube to one of 54 inches.

TEST FOR "SEASON CRACKING"

The tube was immersed in a solution of mercurous nitrate for a few minutes. The cracking indicates improper annealing.

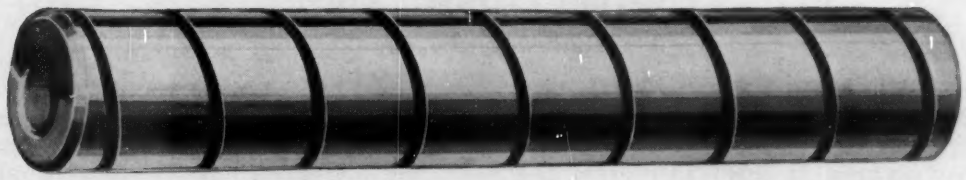
The next step is the extrusion press. The billets will be put into a long furnace, heated to redness, and placed, one at a time, in the container of the press. Here the hot metal will be squeezed through a die to form a rod from two to four inches diameter, depending on the size of tube to be made. The rods will be inspected, cut to length, heated to redness and pierced on a Mannesmann machine. This hot rod is rotated rapidly and forced over a mandrel. These hot working treatments refine the structure and render it more dense, as may be noted when tests applied to finshed tubes are judged; they will pass all the physical tests required by the A. S. T. M. and the U. S. Navy.

The pierced rod—now a tube — will be pointed and reduced on draw benches as were those of Admiralty metal.

Brass tubes, made by the process of casting around a collapsible core, cannot be compared with those made by the two methods indicated. In the first place, the metal isn't worked enough; secondly, unsound metal can pass through the draw benches and may not be discovered until out into service — sometimes with disastrous results.

Verily, condenser tubes must be sound to endure the temperature of cold water on one side and steam on the other, while receiving a baptism of salt water, mud, and barnacles.

Synthetic Fuels. The Counte Scientifique du Petrole of France is carrying out a very exhaustive inquiry into the work accomplished by the laboratories and other research bodies of France in the synthetic production of fuels. Some very satisfactory results are reported and Professor Mailhe, of Toulouse, claims that sufficient progress has been made with the economic treatment of vegetable oils with catalysers to warrant the belief that the production of fuels from vegetable oils on an industrial scale is on the verge of realization.—*The Engineer, London, England.*



A Hyatt roller

Hyatt Rollers Are The Distinguishing Features Of Hyatt Roller Bearings

THE continued satisfactory service of Hyatt Roller bearings in machinery of all kinds through the past thirty years is due to their anti-friction elements—the Hyatt rollers.

These rollers are wound cold from long, flat strips of high grade alloy steel. They are carefully heat treated to make them tough and hard and are then carefully ground to close limits.

A group of these rollers held in a strong cage and rolling between hardened steel sleeves or races constitutes a Hyatt roller bearing.

Due to the design of Hyatt rollers and to their superior steel and careful manufacture, the following advantages result.

Friction reduction: Because of their true rolling motion Hyatt bearings eliminate at least 50% of the dragging friction of plain bearings. This results in worth while saving of power and in long life.

Durability: The alloy steel rollers are of the proper hardness to give years of service under the severest conditions of loads and shock loads without appreciable wear. Some Hyatt line shaft bearings at the Greenfield Tap and Die Corporation are still in use after thirty-three years of continuous service. These bearings usually outlast the useful life of a motor car. They have been in operation over fifteen years in coal mine cars without requiring replacement.

Lubrication: The spiral slots in the Hyatt rollers continually spread the oil over all the bearing surfaces and being hollow the rollers afford ample oil capacity for three or four months operation in most machinery. This results in at least an 80% saving in lubrication material and labor.

In any machinery you design now or when you get into practical work after graduation it will pay you to carefully consider the advantages of Hyatt roller bearings.

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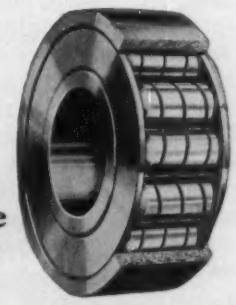

High duty type of Hyatt roller bearing

Open House Night

(*Continued from page 12*)

matic lathes, electric welders, complicated turning and grinding machines and, in fact, nearly every modern machine and tool may be seen in this laboratory. The recent addition and use of the Interferometer is an example of how each department keeps up to the second with new equipment for the students' use. This apparatus measures material sizes accurately to one millionth of an inch through the utilization of the change of wave length of light rays under certain conditions. Viewed by use of this Interferometer, the distortion of a five-inch steel bar by the pressure of a finger on it is plainly visible and may be measured.

Passing on to the textile laboratory, where recent refinements have also changed its aspect slightly, the visitors will see various machines in operation performing the many steps from handling the raw material to the finished fabric. In like manner, complete operations will be conducted in each of the important places. The numerous chemical and electro-chemical laboratories will be open with interesting exhibits in each. Most of the extensive electrical equipment, including generating, transmitting, radio and numerous other phases will be in operation. In the Physics Department, several fascinating experiments with natural phenomena are planned. The Aeronautical Wind Tunnel will be in operation showing how the performance of any airplane or airship is accurately determined before the actual "ship" is built. Here tests will be conducted on model airplanes and parts while the Automotive Laboratory will be open showing how tests of auto and airplane engines are conducted. In the Heat Laboratories, one recalls the familiar "Ice and Coal" advertisements, for here refrigerators and furnaces are found side by side. Recalling the modern theory that "there is no such thing as cold—it merely denotes lack of heat" gives an insight into the nature of thermal experiments in this department. At present, much research is under way in obtaining new materials for more efficient insulation of heat. Operations in the ore dressing department, exhibits in the division of Biology and Public Health, photoelasticity apparatus, and the X-ray rooms, completely described in another part of this issue of *The Tech Engineering News*, still fail to complete the list.

Photoelasticity and its applications are among the most recent important advances in science and it is gratifying to know that Technology is responsible for this and leading in its development. Prof. Paul Heymans, sponsor of photoelasticity, and Prof. Hovgaard, it will be remembered, obtained invaluable data for determining the stresses in rigid airships by loading a model of the ZR-1 (now Shenandoah), and studying its behavior by photoelastic methods. In very complex structures, this method has been foremost in obtaining the "indeterminate stresses" when ordinary means failed. The success and accuracy of these tests, which were verified by comparison with actual stresses measured when the Shenandoah was built, led on to a survey of the "Causes of Failure of Metal Surfaces Shown by Polarized Light" described in the January issue of *The Tech Engineering News*. Much of the apparatus and many models used in this work will be exhibited on Open House Night.

While the greatest mention has been made of technical equipment and paraphernalia, the many other phases of the Institute have not been neglected. The routes will also include the library in the great dome where the largest and best collection of technical literature in the continent is available for the use of students. The recent acquisition of the famous Vail Collection adds interest to these halls. Numerous museums throughout the buildings, such as the collection of fossils and mineralogical specimens in the Mining Department and the Natural Museum of the Biology Department, will be open. The main lecture halls, study and drafting rooms will be visited while the facilities and work of the Military Science Division have not been slighted. The athletic quarters and Walker Memorial, the student social center, are not included, but these will be open and may be visited upon request.

Having completed the tour, the guides will dismiss their parties in the new Pratt Building where the designs of students in Aeronautics and in Architecture will be displayed. Before leaving, they may visit the Ship Modeling rooms and the Museum containing the "Clark Collection of Marine Prints and Models," and the "Marine Collection, gift of Charles H. Taylor." These include some of "Tech's Auxiliary Paper Ships" and many of "Tech's Paper Navy" prints. Recently Mr. Taylor generously donated about seventy-five prints of his collection to the Marine Museum of Technology, which formerly consisted chiefly of the "Clark Collection." When com-

(*Continued on page 34*)

MACHINE TOOL LABORATORY

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X-Ray Analysis

(*Continued from page 14*)

light is dependent upon the intensity of the X-ray beam.

For castings, however, this method is neither feasible nor safe and the image is recorded on a photographic film which can be printed and reproduced in the usual way. Because of the very penetrating rays which are employed, it is difficult to adequately protect the user of the screen from their harmful effects.

A very high powered machine is necessary for work on metals and the X-ray laboratory of the Department of Physics, Massachusetts Institute of Technology, is very fortunate in possessing one of the few machines of this type in the country. This machine, which is shown in Fig. 1, consists of a special Coolidge type X-ray tube which is supplied with a current of a few milliamperes at 265 kilovolts from a high tension generator. The penetrating power of the radiation increases with the applied voltage and when operating at this voltage people working in neighboring rooms must be protected from the harmful effect of the rays which will pass readily through several feet of wall. The room in which the machine is placed is completely, except for the floor, lined with sheet lead one-quarter of an inch thick and weighing about eight tons. The machine is entirely controlled from outside of this room.

Metals compose the major portion of the material with which the engineer has to deal and all metals have a crystalline structure. The structure of a crystalline material is unique in that the atoms are arranged in a regular, definite fashion. Employing a scheme which is similar to the well-known method of measuring distances by the interference of light, X-rays can be used to measure the distance between the atoms of a crystalline material. This enables one to determine the unit cell upon which the crystal is built and it has been found that every element and chemical compound which occurs in crystal form has a characteristic unit cell. Thus we have a very useful method of analysis not only of the component parts of a material but also of their state of combination. Results of crystal analysis have given us a great deal of information as to the internal arrangements of alloys, have explained very satisfactorily the question of plastic deformation, and why slip takes place in metals along certain planes rather than others. Some recent work done at the Institute has cast considerable doubt upon the existence of the so-called "amorphous" metal which formed the foundation of the theory of hardening by cold work. Crystal grains which are far too small to be seen under the microscope are indicated by X-ray analysis, and the amorphous metal proved to be composed of very fine crystal grains.

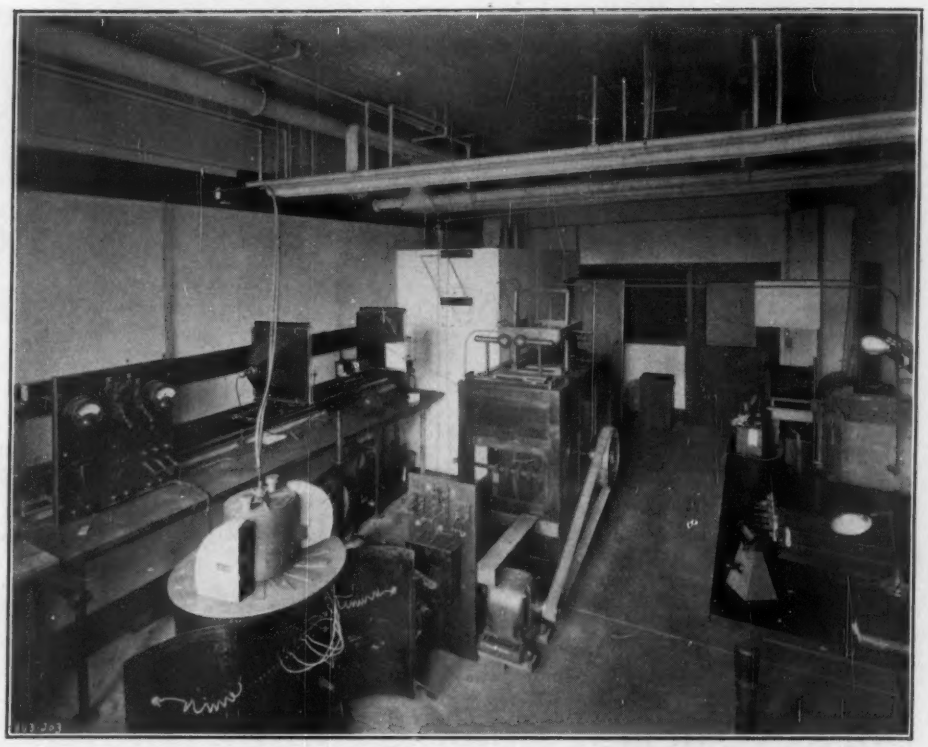

Figure 2
PART OF THE X-RAY LABORATORY
The diffraction apparatus is in the left foreground.

This application of X-radiation belongs to the metallographer rather than to the engineer, but the co-operation between the two is bound to be very close and it is important for the engineer to be familiar with all the possible means of improving the materials with which he has to work and for the metallographer to keep in touch with the behavior of the materials in actual use. Of course the method of crystal analysis has applications to many other substances besides metals. Fig. 2 shows a standard form of apparatus for obtaining the X-ray diffraction patterns of various types of materials.

The X-ray laboratory of the Department of Physics has recently undergone extensive improvement, and has been greatly enlarged and now has a very complete equipment for investigating the practical application of this interesting and useful type of radiation as well as the more theoretical problems connected with the nature and production of the rays themselves. This laboratory is giving regular instruction in industrial radiology to both graduate and undergraduate students, and is believed to be the only laboratory in the country furnishing such instruction.

Testing Underground Cable of 110,000 Volts. A field test of a 110,000-volt underground cable is being made through a separate oil switch outside of the lightning arresters of the North Albany Station of the Adirondack Power and Light Corporation, by the General Electric Co. It is thus subject to all the surges, overvoltage stresses, etc., which might occur on the system proper.

The erection of more centrally located generating stations necessitates preparation of underground cable, capable of operating at higher voltage than even that of the 66,000-volt cable which is now in operation on the system of the Cleveland Electric Illuminating Co. Transmission lines of very high voltages cannot be taken into cities by overhead systems. Therefore, it has usually been necessary in the past to stop the high voltage transmission on the outskirts, with the distribution center remote from the consumption center. This test length of cable has a core of stranded wire wrapped in oil-saturated paper insulation and enclosed in lead sheathing.—*Power.*

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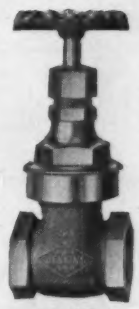

Fig. 370
Screwed, Jenkins Standard Bronze Gate Valve

THE metallurgist plays an important part in the manufacture of Jenkins Valves, for a good valve must contain good metal. Metal is bought on analyses, and to maintain a high standard, analyses of cast metal are regularly made. Metal is mixed and charges are prepared under the supervision of competent metallurgists.

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Fig. 142
Flanged, Jenkins Standard Iron Body Globe Valve

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Cuckoo Ideas

(*Continued from page 5*)

Simple things, very simple things, but the world rewards men who can hatch out these elementary ideas by paying them millions of dollars. By and large, our recompense is commensurate with what we contribute to humanity.

The great value of any education does not lie in the facts which we may accumulate, but rather in the training of our ability to think and to study properly. Real teaching is something more than, "handing out valuable information to be returned by the student in a more or less mangled form." Teaching is the guiding of the learning instinct. The swallowing system is all wrong. It is the ability to analyze and to estimate the value of facts as distinct from assumptions, and the desire to secure all the essential facts which should be developed in the student.

The priceless gift of independent thought is very evident in children, but they have not yet learned how to direct it. A certain little girl whom I know, discovered at the mature age of five one of the insoluble problems of the universe.

"Daddy, who made God?"

"Nobody knows, little sweetheart," he replied, and returned to the reading of his *Evening Transcript*. After a few moments he was interrupted again.

"I know, Daddy; first he got his hand and then he made himself."

This is an original idea alone, without the substantiation of facts. The youth who defended a literal interpretation of the Old Testament story of Balaam and his experiences by advancing the theory that if man can make a machine talk, perhaps God could make an ass talk, had, of course, failed to recognize that the machine merely reproduces, whereas Balaam's steed created, but the seeds of reasoning by analogy were there.

College is to train us to think accurately, but above all to think. The self-made man who has the ability to do it will outstrip the so-called educated man who has not achieved the ability to think for himself.

It is strange about thinking. When you turn on your radio the energy in the battery gradually becomes exhausted, but the more you think the greater is your capacity for thought. If you lose heart when the professor begins to revolve something through angle O or to pursue an elusive $\frac{dq}{dt}$ across the blackboard, then your studies become merely the dull giving back of formulae, but if you try to reason the thing out for yourself you will be rewarded by an increased capacity for independent thinking and by the satisfied feeling which attends the discovery that the author agrees with your conclusions.

Ideas are what result when your brain goes to work. They are never inherited, but belong entirely to you who create them. You are responsible for your thoughts, and upon them depends entirely your achievement in life, for in the largest sense the only task you will ever have is to take charge of your thoughts. What you do with them involves everything in your life.

If you can only learn to exclude the cuckoo ideas and to properly incubate and hatch your own wren children, even though they are unable to fly by themselves at first, it will some day be unnecessary for you to hang your diploma on the wall—so that people may know that you are educated.

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The trouble is that the boy on the end, in "cracking the whip", cannot go two ways at once. He tries to follow the line 'round and 'round, but a force is created which flings him off sideways.

So do the wheels of your motor car try to go merely 'round and 'round, but sliding against them sidewise at the same time is the whole weight of the car, pushed over by the very slope of the pavement.

Or look at a moving street car, lunging from side to side against the wheels. And you also know that a belt which is driving machinery never seems to run quite true; you can see it weave always from side to side, whipping the pulleys while they revolve.

In fact, there is rarely, if ever, any revolving motion which does not involve some of the sidewise or pushing motion called Thrust, which must be taken care of by the bearing or else there is compromise!

You can be sure that bearing compromise is avoided in the motor car, farm implement or industrial appliance equipped with Timken Tapered Roller Bearings because Timken Tapered Roller Bearings are inherently dual duty bearings. Timken Dual Duty is the ability to carry the motion or load from both directions —from ALL directions—all at once.

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TIMKEN *Tapered Roller* **BEARINGS**

Virginian Electrification Project

(*Continued from page 9*)

ance of all the units. The necessary equipment for each motor is mounted in the motor control rack on top of each traction motor. The auxiliary motors driving the blowers and rheostat pump are of the three-phase squirrel-cage type. Power for these motors is obtained from an open delta connection on the transformer and phase converter at an approximate potential of 400 volts.

A comparison of results obtained under the steam operation with those expected under electric traction brings forth some interesting facts. At the present time, the section which is undergoing electrification is divided into two locomotive districts. The first section is from Mullens to Princeton, a distance of 35 miles. The other engine district extends from Princeton to Roanoke, a distance of 97 miles. As previously stated, the coal from the various mines is collected in the Elmore Yards at Mullens, West Virginia. Under the present system of steam operation, three Mallet-type locomotives are required to haul a 5,500-ton train from Mullens to the top of Clarks Gap Mountain at an average speed of 7 miles per hour. From this point, one road locomotive with the helper takes the train to Roanoke. On the other hand, under electric operation, it is planned to have but one locomotive district from Mullens to Roanoke. Two electric locomotives will haul a 6,000-ton train from Mullens to Clarks Gap at a speed of 14 miles per hour, which is double the speed obtained under steam operation. At Clarks Gap, the tonnage of the trains will be increased to 9,000 tons, and one electric locomotive will haul the train to Roanoke at speeds of 14 and 28 miles per hour, depending upon the grade conditions. On the run to Roanoke, heavy grades are descended, however. A 9,000-ton train will be held at a constant speed of a little more than 14 miles per hour by means of regenerative braking. The regenerative feature is of prime importance, as it reduces the wear and tear on the brake equipment and also sends power back into the line which can be used by locomotives ascending the heavy grades. To handle the tonnage on which electrification is based, approximately forty-four road-type Mallet locomotives and twenty pusher-type Mallets would be required to handle the trains from Mullens to Roanoke. Under the electrification program, sixteen three-unit locomotives will perform this service. The initial installation calls for twelve of these locomotives, and they are rapidly going forward to completion at the East Pittsburgh Works of the Westinghouse Electric & Manufacturing Company.

Today, the railroads of the United States face the problem of increasing the capacity of their lines in order to handle business in an efficient and economical manner. Laying tracks parallel to the present points of congestion is one solution of the problem. However, the real solution of the problem is electrification. This statement is proven by statistics taken from the electrified railroads in this country and in Europe. Data from these railroads indicate that electric traction speeds up the movements of trains, increases the efficiency and decreases the operating expenses. Consequently, it is safe to conclude that the railroads can solve their problems of congestion and inefficiency by resorting to electrification.

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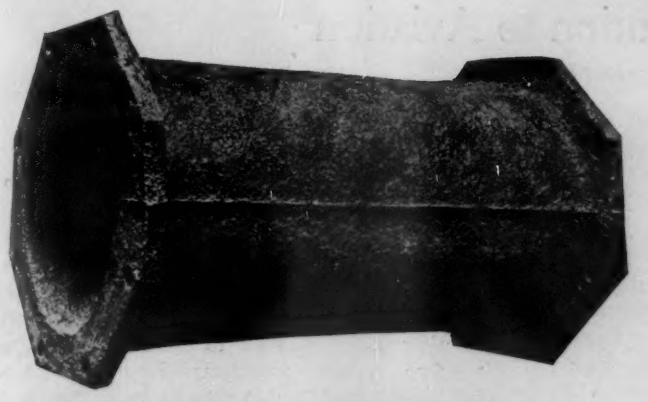

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A HUNDRED years before Napoleon was born, before his wars scourged Europe, before the French Revolution raged, this Cast Iron Pipe was laid, in the reign of Louis XIV, to supply water to the fountains of Versailles.

To the patient researches of M. Blanc, Chief Inspector of the Water Service of Versailles and Marly, into dust-covered volumes in the garrets of the Palace of Versailles, we owe the proof of its antiquity.

A report from the Director of the Water Service, M. Blanc's chief, says: "From their actual state of preservation, which is excellent, excepting the assembly iron bolts, these conduits seem to be able to furnish service for a very considerable time longer."

The high resistance of this Cast Iron Pipe to corrosion may be judged from the clearness of the fine "parting line" produced by the old horizontal method of casting.

THE CAST IRON PIPE PUBLICITY BUREAU
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CAST IRON PIPE

Our new booklet, "Planning a Waterworks System," which covers the problem of water for the small town, will be sent on request

Send for booklet, "Cast Iron Pipe for Industrial Service," showing interesting installations to meet special problems

How To Know a Good Bronze Bushing When You See It

There are certain things which are judged by the test of time, rather than by an individual investigation. They are accepted because of the good reputation which time and trial have given them.

You can identify a good bronze bushing bearing by a metallurgical analysis —or by merely specifying a Bunting Bushing Bearing. We will gladly tell students anything we have learned in this industry.

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"Many a man has failed because he couldn't 'figure it out.'"
—Baby Bunting

BUNTING
PHOSPHOR BRONZE
BUSHING BEARINGS
PATENTED

Technology's Contribution to Aviation

(*Continued from page 13*)

thoroughly into the principles underlying the design and efficiency of aircraft power plants. To keep abreast of the tremendous developments in aviation, the Institute equipment will be augmented by a new and larger photoelasticity laboratory which is now under construction.

To practically every phase of the development of aviation the Institute has contributed—either as the Massachusetts Institute of Technology or as faculty members in the individual capacity of consulting engineers—from the design of aeroplane landing gears to the testing of wing fabrics. Not solely to the technological arts and sciences, however, has the Institute confined itself. It has generously responded to the demand of the aviation industry for trained men. It is in this latter contribution that Technology has won a position of leadership in the progress of aviation.

The Institute has contributed largely to the training of aeronautical engineers. More aeronautical engineers have been trained at the Institute than at all the other American universities combined. During the past year at McCook Field, of the officers and technical civilians, at least one-eighth are graduates of Institute intensive courses. Of the seven or eight companies now engaged in the production of aircraft for the United States Government, only one has not in its employ one or more Technology graduates in an aeronautical engineering capacity.

The reasons for the Institute's dominant position in the field of aeronautics are evident upon a review of its course of instruction. Although the aeronautical engineering course officially began in 1913, instruction in this subject was offered during the five years previous by Professor Lanza and Mr. A. A. Merrill. Several theses were performed with the aid of Professor Lanza's wind tunnel during 1909 and 1910. As a culmination to the rapidly growing interest in aeronautics, the regular course of instruction was established in 1913 under the direction of Commander Jerome C. Hunsaker, U. S. N., who subsequently directed the designing of the Shenandoah. The course was given by Commander Hunsaker for three years, his assignment to this duty terminating in 1916. It was then carried on for another year by a student in Commander Hunsaker's course.

During the World War the course was supplemental to the training of officers for the Army and Navy, of whom more than eighty qualified as aeronautical engineers.

After the war the aeronautical engineering course received renewed impetus. At present it is in charge of Professor Edward P. Warner, a member of the class of '17. Its magnitude is ample testimony of Technology's determination to remain in the front rank of aviation development.

With such a distinctive array of contributions to the development of aviation, the Massachusetts Institute of Technology has earned the respect and admiration of the Government and of the industry. Although the primary functions of a scientific school are to teach principles and to train men, the consequent necessity of assisting more completely in the development of aviation and of aiding the aeronautical industry has compelled Technology to embrace in its search for truth the entire science of aviation.

for Insulation

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Made of extra quality cotton yarn, carefully inspected and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds and colors, for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.

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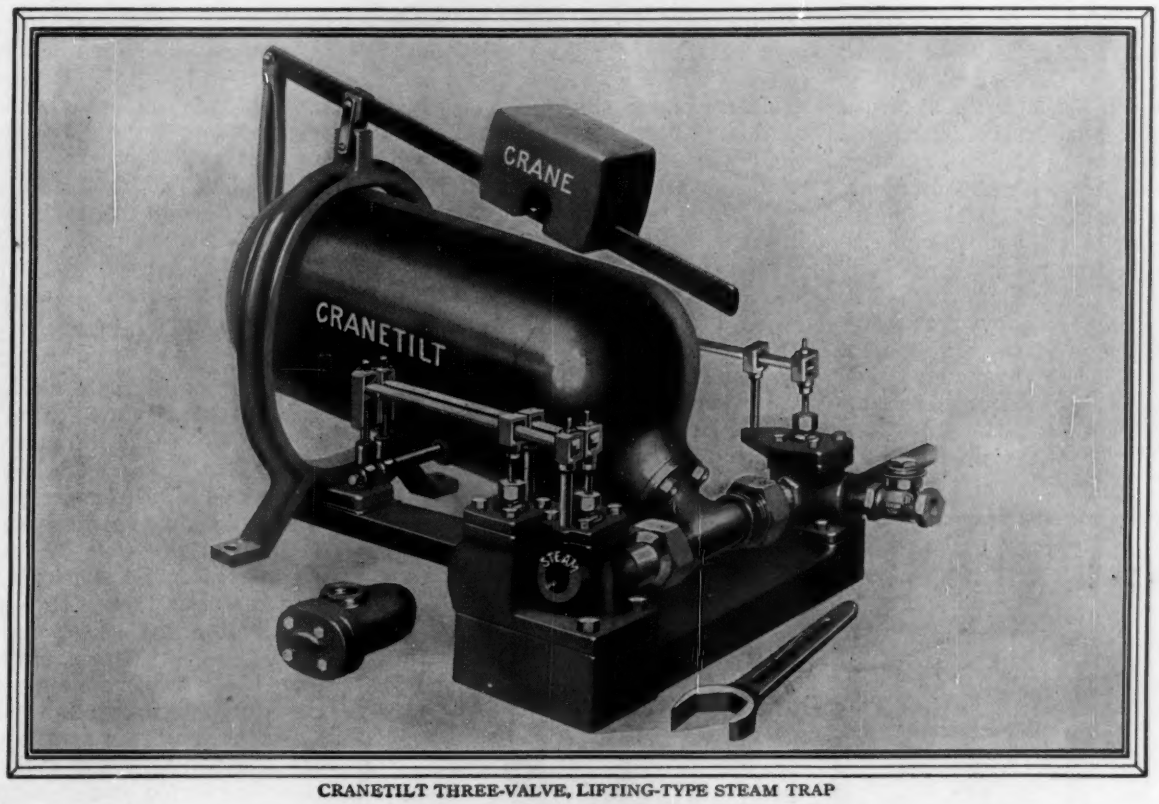

CRANETILT THREE-VALVE, LIFTING-TYPE STEAM TRAP

WHAT IS A STEAM TRAP?

A successful steam trap should be a passageway for water and a barrier to steam. It prevents the loss of any steam while it disposes of the accumulated condensation from pipe-lines and headers. Or drains receivers, drip pockets or steam using appliances. It is automatic, performing its important function without attention.

Steam traps of the right type, properly arranged, will return hot condensation directly to the boilers as pure feed water. Conserving the "heat of the liquid" of this condensate, they effect large fuel economies. They are the most economical devices on the market for boiler feeding. Steam traps can also be used to draw condensation from low pressures or vacuums, discharging directly into a higher pressure, and metering the discharge if desired.

Cranetilt traps perform these and similar functions in many important power plants, in chemical plants, paper mills and oil refineries. Their operation is fully described in a Crane publication entitled "Condensation." We will be glad to send a copy to any engineering student who writes for it.

CRANE

GENERAL OFFICES: CRANE BUILDING, 836 S. MICHIGAN AVENUE, CHICAGO
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CRANE EXPORT CORPORATION: NEW YORK, SAN FRANCISCO
CRANE-BENNETT, LTD., LONDON
CIE CRANE: PARIS, NANTES, BRUSSELS

Open House Night

(Continued from page 24)

bined with the larger Clark Collection and with future gifts that will follow, the "Technology Collection" will be the nearest complete of its kind owned by any educational institution in the United States and possibly anywhere in the world. Accurate models depict each major change in marine architecture from the early junks and galleys to the modern "floating palaces," dreadnoughts, and submarines. The important role played by Technology in the recent development of marine engineering, both commercial and military, adds interest to these exhibits.

At the exits, each visitor will receive a souvenir booklet containing a brief sketch of Technology, its history, purpose and advantages. Each undergraduate publication will have a table at this point and distribute copies of their magazines and papers gratis. Time permitting, visitors may return to places in which they found a special interest.

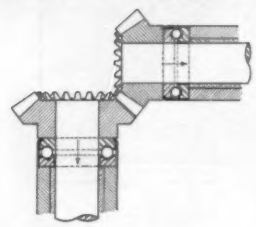
To insure that everyone leaves the buildings when the time limit is reached and after the signals have been given, the Superintendent of Buildings has an effective plan. Lights are extinguished in sequence starting on the upper floor in the center and working down and toward the exits. Janitors on the edge of the dark area guard against anyone being stranded.

The broad scope of Technology's activities and the opportunities it offers, not only to students of engineering, but to Industry and Business in general, make this function especially attractive to people in all walks of life. Plans and arrangements for this year's Open House Night promise to make it the fullest and most successful yet held.

New Mine Alarm. An alarm system to clear men from the mine as quickly as possible was tried recently at the Utica Iron Mine at Hibbing, Minn. Two pints of ethyl mercaptan was introduced into the discharge air line at the engine house by means of an air lubricator. So strong is the stench that it works its way through leaks in the air line and causes the odor to be spread by the usual ventilating system. The mine covers eighty acres and the odor was carried a distance of half a mile to reach the men farthest from the shaft. The speed with which the odor is carried was demonstrated by the fact that the 130 miners after notification, walked half a mile, climbed up 300 feet of shaft and were in the dry house 29 minutes after the liquid was introduced.—*Engineering and Mining Journal Press.*

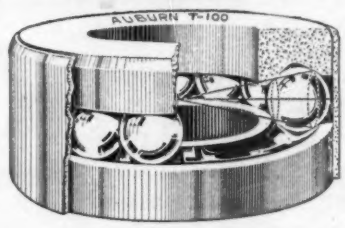
7,150 B.H.P. Gas Engine. A blast furnace gas engine to develop 7,150 b.h.p is at present being installed in the works of the Stavely Coal and Iron Company, Chesterfield, England. It was built in Belgium and is of the four-cylinder, twin-tandem type—two sets of two cylinders in tandem. Bore and stroke are 51 inches by 59 inches. The engine will run at 90 r.p.m. and will be direct coupled to a 5,000-Kw. alternator. The heat of the exhaust gases will be utilized to generate steam. When completed, this will be the largest gas engine in England.—*The Engineer, London, England.*

BEVEL GEARS



have longer life when their thrust is taken by

AUBURN BALL THRUST BEARINGS



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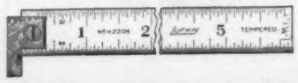

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All of Superior Quality and of Interest to Every Progressive Engineer

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THE FLAME THAT FIRES

COLLEGE athletic teams illustrate forcibly one truth—men achieve by inspiration. The bleachers' cry of "Hold 'em; Hold 'em!" has kept many a goal line uncrossed. "Touchdown! Touchdown!" has scored countless victories.

In an engineering organization like Westinghouse, this inspiration comes from engineering executives — men who correlate, organize, administrate, and inspire. They are engineers first, but engineers with the power to enlist the best of other men.

Many derived their own first inspiration from the Founder, George Westinghouse himself. He took a contract for electrifying the New Haven Railroad, for example, before the apparatus had even been designed.

"Now I've dropped you into the middle of the pond", he told his engineers. "It's up to you to swim out".

There was plenty of swimming—but Westinghouse knew his swimmers.

As has been true since organization began, the demand for men who can develop into leaders is far, far short of the supply. Westinghouse welcomes them. All industry welcomes them. Organizations lead because men, in turn, lead them.

This advertisement is seventh in a vocational series, outlining the fields for engineering achievement in the Westinghouse organization. A copy of the entire series will be sent to anyone requesting it.

Westinghouse

WESTINGHOUSE ELECTRIC

ACHIEVEMENT & OPPORTUNITY

Ceramic Engineering

(*Continued from page 16*)

tors; the troublesome spark plug porcelain and the small metallurgical furnaces of twenty years ago, and compare them with the present to realize the tremendous strides made through research and engineering.

And the surface has only been scratched. It has taken a great deal of effort to convince the world's oldest industries with their age-old traditions, that engineering and research could aid them, but having been convinced, the cry is for *research and more research.* Where are the necessary research men to come from? Hardly from the ranks of the four-year men who have had no research training and in whom the research mind, spirit and vision and the necessary patience have not been developed. More than any other one thing the ceramic industries need men who have been trained to think in terms of physical chemistry as applied to silicates and men who can think in mechanical terms as applied to ceramic processes.

Research in ceramics is now being carried on at the various Ceramic Experiment Stations of the United States Bureau of Mines; at the Ceramic Laboratory of the United States Bureau of Standards; by the Refractories Manufacturers' Association at the Mellon Institute; in the several ceramic departments of the universities and in the research laboratories of the Portland Cement and Terra Cotta Associations; the General and Westinghouse Electric Companies and many other associations and individual companies.

Unsolved problems present themselves without number. The clay products industry wants to know the "why" of the plasticity of clay and how to control it; how to eliminate lamination; how to treat difficult drying clays commercially in order to use them; how to eliminate hand labor in many of its processes. The potter wants machines to produce his present handmade product and to replace European with American raw materials. The refractories manufacturer also wants machines developed to replace his skilled labor—one of the problems Professor Norton of Tech has been working on for the past several years. He also wants to know why refractories distintegrate in oil-fired furnaces and how to produce a product to which clinker will not adhere in stoker furnaces. The glass, enamel, terra cotta, cement, lime and other industries all have similar problems too numerous to mention, the solution of any one of which will put the successful researcher's name in the Ceramic Hall of Fame.

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INCORPORATED
Engineers and Contractors
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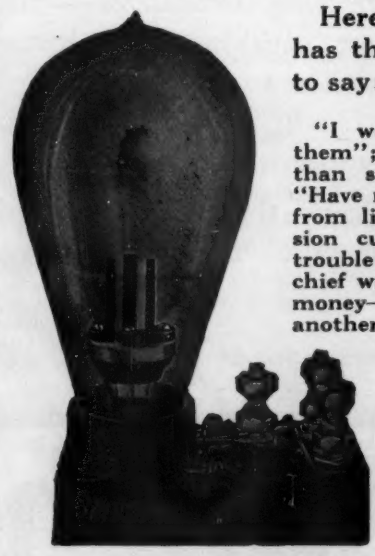
Power Plant Apparatus
79 Milk Street **BOSTON** Tel. Congress 1810

Quality—Service

Black and Galvanized
RUST-RESISTING
SHEETS
TIN AND TERNE PLATES
We manufacture SHEET AND TIN MILL PRODUCTS for all purposes—American Bessemer, and American Open Hearth Steel Sheets, Keystone Copper Steel *rust-resisting* Sheets, Apollo Galvanized Sheets, Formed Roofing and Siding Products, Culvert and Flume Stock. Sheets for Special Purposes, Roofing Tin Plates, Bright Tin Plate, Black Plate, Etc.
AMERICAN SHEET AND TIN PLATE COMPANY, Frick Bldg., Pittsburgh, Pa.
Every engineer should have our booklet describing Keystone Copper Steel.

Rust-resistance

VAC-M Arresters Will Protect Fire Alarm Apparatus
against lightning and other electrical disturbances.



Here's what a chief who has them in service has to say:

"I would not do without them"; another writes, "More than satisfactory"; a third, "Have never had a fuse blown from lightning or high tension current"; another, "A trouble saver"; still another chief writes, "It has saved us money—fine results"; and another chief writes, "The installation has been very satisfactory. We have standardized on this equipment, and will equip any future installations in the same manner," etc.

The National Electric Specialty Co.
Toledo, Ohio

INDUSTRIAL BUILDINGS SHOULD BE WELL LIGHTED.

From the employer's viewpoint, the big difference between men who work out of doors and those who perform tasks inside the building, is the factor of light. Daylight furnishes sufficient illumination outside during the daytime working hours for men to pursue their tasks efficiently and safely. But the proposition of getting enough daylight into the interior of industrial buildings, requires some thought.

It is not a difficult problem by any means, and any employer can take advantage of daylight and utilize it for lighting his building during the daytime, if he desires. It is an excellent light, especially suitable for the eyes, reducing eye strain and eye weariness to a minimum, and has the great economic advantage of costing nothing.

To utilize daylight to the utmost, we must first provide means for allowing daylight rays to enter the interior of buildings in sufficient quantity—namely, proper and adequate windows and skylights. Many excellent instances of buildings designed with a due regard to the importance of daylight lighting can now be seen in many of our industrial cities. Such buildings present the appearance of being practically all windows—"window walled," as they are termed—and this type of daylight construction is coming rapidly into favor, because it constitutes a more healthy building for large numbers of employes, both from the lighting and ventilation standpoints.

Among those who have constructed this type of modern industrial building may be mentioned: The Shredded Wheat Co., Gillette Safety Razor Co., Lyon & Healy Piano Co., H. J. Heinz Co., Corona Typewriter Co., Skinners Macaroni Co., Grape Juice Co., Dodge Bros., Nelson Valve Co., Piston Ring Co., Remington Arms Co., and a great many others.

The Larkin Co., Philadelphia, has erected a building almost entirely glass, 85% being windows, and the Loomis Breaker, operated by the D. L. & W. R. R. Co., Nanticoke, Pa., is literally a glass house, being 93.5% of glass. The new buildings of the Winchester Repeating Arms Co. have an average glass area of 58%.

An investigation covering 18 buildings constructed by the Aberthaw Const. Co., Boston, shows that the average window area is 57.5%.

These figures indicate how important the subject of lighting is now considered by employers of industrial labor, and how well the idea has been carried out by the architects and engineers, in order that all parts of a building may receive sufficient daylight. But, in addition to providing ample window space, there is another factor which is equally important, and that is, equipping the windows with the proper glass.

The bright direct rays of the sun should not be permitted to strike the eye, and we must provide a means for reducing the glare to rays which will not be too bright. This is accomplished by glass especially manufactured for industrial windows, known as Factrolite. This glass possesses the property of breaking up the intense rays of the sun and diffusing the light into the interior of the building in proper portions, solving the problem of sun glare.

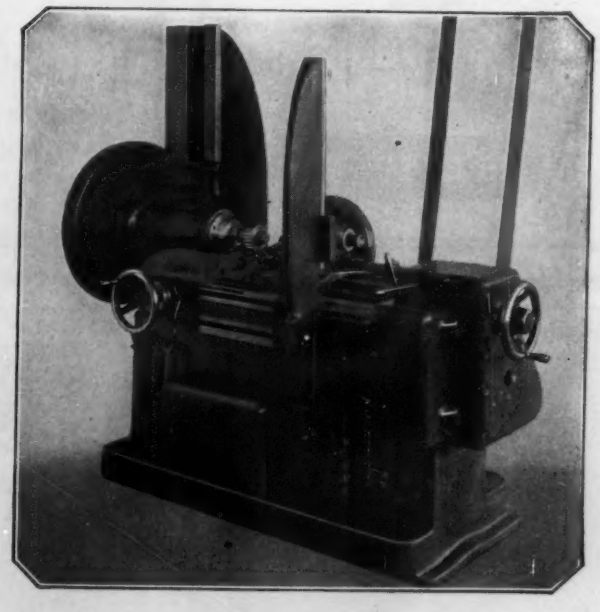
If you are interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

MISSISSIPPI WIRE GLASS CO.,
220 Fifth Avenue,
St. Louis. New York. Chicago.

Why these gears run quietly

THERE are two big reasons why Brown & Sharpe Automatic Gear Cutting Machines cut silent, smooth running gears. They are rigidly constructed so that they can take heavy, accurate cuts without setting up destructive vibrations. Also they have an extremely accurate index wheel of large diameter which insures accurate spacing of teeth. Gear Cutting Machines must have these two important features if they are to cut quiet running gears.

Brown & Sharpe Automatic Gear Cutting Machines, due to their lasting accuracy are known and used all over the world.



BROWN & SHARPE MFG. CO.
PROVIDENCE, R. I., U.S.A.

Professional Notes

(*Continued from page 20*)

land." He brought with him a fine set of slides illustrating ice conditions encountered in our New England streams, and explained in detail the effect of ice coverings on meter readings and the method of calibration to correspond with normal flow.

On Friday February 20, one of the most important meetings of the year occurred. The Society took part in a joint meeting with the engineering societies of Tufts, Harvard, and Northeastern at the invitation of the Boston Society of Civil Engineers to hear Robert Ridgway, Chief of the Board of Transportation of New York City, speak on New York's transit system. Mr. Ridgway has been recently elected President of the American Society of Civil Engineers. His lecture was illustrated with movies and lantern slides and dealt largely with the construction and operation of New York's famous elevated and subway systems, the construction and operation of which is probably one of the outstanding engineering achievements of the age.

BUFF Instruments

save time—error—calculation

Engineers and contractors know that BUFF performance is accurate and sure—on all sorts of work from running location lines to giving "neat lines" on important bridgework—without having to adjust the transit once.

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Selected Grades

Anthracite

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BURTON-FURBER
COAL COMPANY
50 CONGRESS STREET
BOSTON

Recent Books

(*Continued from page 17*)

Combustion in the Power Plant, by T. A. Marsh. New York: D. Van Nostrand, 1924. 249 p.

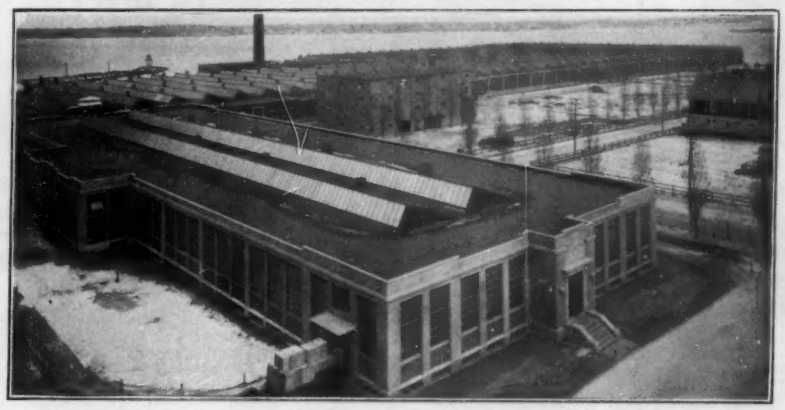
A very practical discussion of the problem of efficient coal burning. It takes up the different grades of coal suitable in various localities, stokers suitable for handling these coals, the maintenance and operation of furnaces, draft, ash-disposal, etc. Primarily intended for operators of large power plants, it is also of value to executives as an aid in checking up operating conditions.

Einstein's Theory of Relativity, by Max Born. Professor of Theoretical Physics, University of Göttingen. E. P. Dutton & Co., New York. 290 p.

After relating the various hypotheses of celestial mechanics, which have been advanced, the author gives an account of the Einstein theory and how it differs from other "world systems." It is a very clear treatise and readily understandable to one of technical training; but it loses something by omitting all advanced mathematics and describing minutely elementary principles of mechanics and optics in an attempt to appeal to the non-technical reader.

Henley's 222 Radio Circuit Designs. The Norman W. Henley Co. $1.00.

This volume is intended primarily for use by amateurs interested in building their own sets. It contains a brief non-technical discussion of such topics as frequency, wave length and tuning and also complete diagrams of all the most popular circuits. Two hundred and eighty-four illustrations are used in presenting the subject. It would make a handy reference book even for students of radio engineering.



One of the finest textile mills in world built by Wm. T. Reed Co. Several repeat orders have been received from this firm

WILLIAM T. REED CO.

Building Construction

200 DEVONSHIRE STREET, BOSTON

We are organized and equipped for the efficient handling of mercantile and industrial building construction of all descriptions

KOEHRING

Paving in Peru

IT is not only in this country that Koehring pioneers, but in sections all over the world the Koehring paver is blazing new concrete trails of progress, development and civilization.

In Peru, for instance—paving streets of Lima and thirty-two of its other principal cities, building the important motor highway between Lima and Callao and pushing paving work in Cuzco, Arequippa and Ayacucho. The Koehring paver is found taking its part in this major public improvement.

Koehring Pavers and Mixers are identified with noteworthy construction projects in all parts of the country and the world. "Koehring Heavy Duty" is a symbol signifying equipment of the highest grade, built to deliver maximum operating service over a period of years.

KOEHRING COMPANY
MILWAUKEE WISCONSIN

Manufacturers of Pavers, Mixers — Gasoline Cranes, Draglines, Shovels

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers courses each of four years' duration, in Civil, Mechanical and Electrical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy, and Geology and Geological Engineering; Architecture and Architectural Engineering; Chemistry, Chemical Engineering and Electrochemical Engineering; Biology and Public Health, and Sanitary Engineering; Physics, General Science and General Engineering; and in Engineering Administration. These courses lead to the Degree of Bachelor of Science.

To be admitted to the first-year class, applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History, and French or German and one elective subject. Examinations are required in all subjects except Chemistry, History and the elective, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June, applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago, and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted, without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy and Doctor of Science are also offered. Special Research Laboratories of Physical Chemistry, Applied Chemistry and Science have been established.

PUBLICATIONS

Bulletins of General Information, Courses of Study, Summer Session, Advanced Study and Research; and the Report of the President and the Treasurer.

Any of the above-named publications will be mailed free on application.

For information, address

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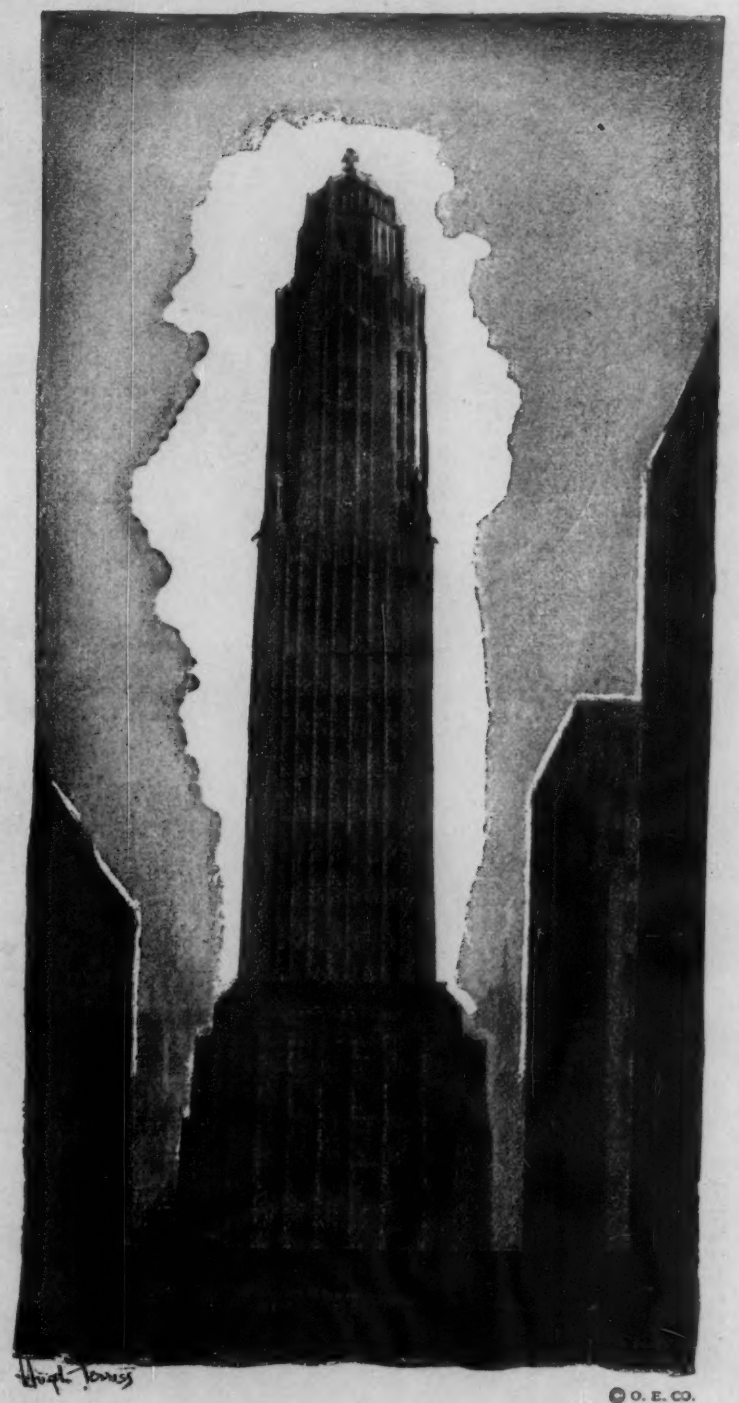
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, MASS.

The Bush Building
New York City

HELMLE & CORBETT
Architects

Drawn by Hugh Ferriss



"A Noble Profile"

© O. E. CO.

FAR more strongly than most churches, this great tower of commerce bespeaks the real spirit of Gothic architecture—aspiring, rugged, virile—an inspiration for the thinking, creating architect of today. Contradicting the antiquarian, this great tower declares that the spirit of Gothic architecture is a living, organic thing, adaptable to modern problems of accommodation and engineering, and endowed with a future as magnificent as its past.

Certainly modern invention—modern engineering skill and organization, will prove more than equal to the demands of the architecture of the future.

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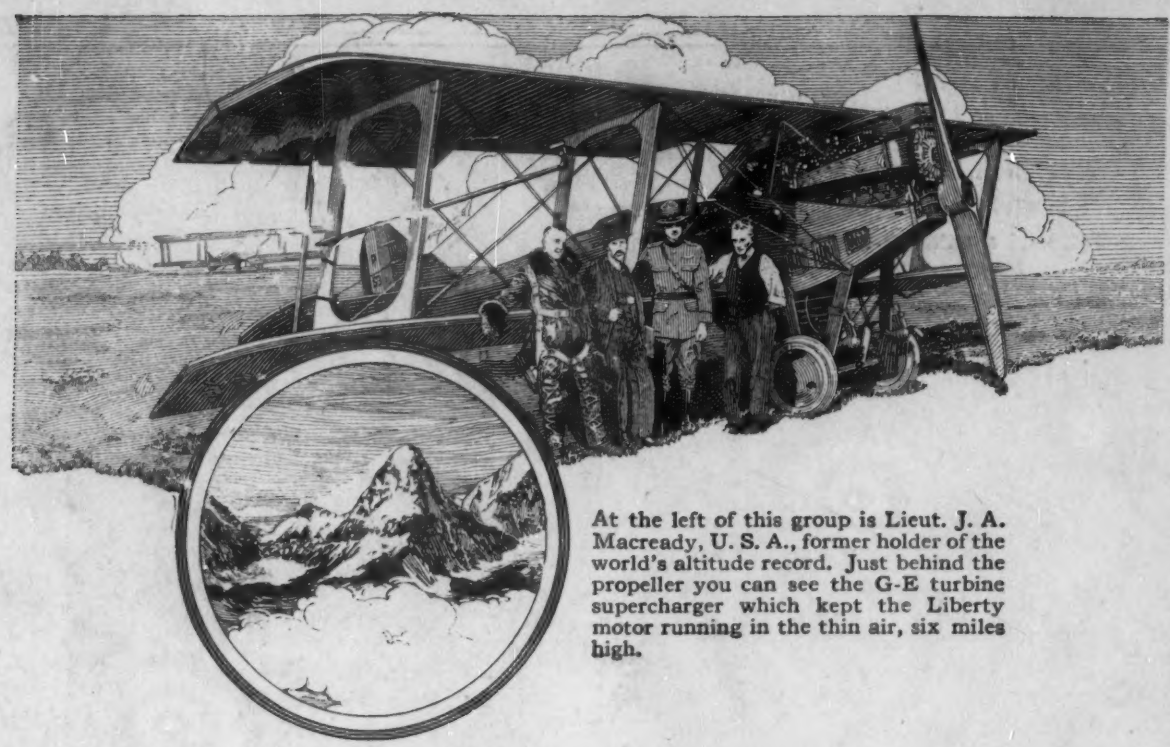

At the left of this group is Lieut. J. A. Macready, U. S. A., former holder of the world's altitude record. Just behind the propeller you can see the G-E turbine supercharger which kept the Liberty motor running in the thin air, six miles high.

Over the mountain by a mile

Year after year, plucky explorers try to climb Mount Everest, the world's highest peak, 29,141 feet high.

With a G-E supercharger feeding air at sea-level pressure to the engine, an airplane pilot can go far higher. Lieut. Macready has reached 34,509 feet over Dayton, Ohio. He would have soared over Mount Everest with more than a mile to spare!

The tasks attempted for centuries in almost every form of human endeavor have been conquered with the aid of electricity, with more than a mile to spare.

The impossible today will be accomplished by men and women now in college. The scientist and engineer are doing their share. It remains for men and women entering upon their life's work to profit by the new opportunities that are constantly appearing in every profession and vocation in the land.

The supercharger is a turbine air compressor, which revolves as fast as 41,000 times a minute—the highest speed ever developed by a commercial machine. It is designed and made by the General Electric Company, which also builds the big turbines that supply electric light and power.

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